Gulf Cooperation Council

EDICT OF GOVERNMENT

GSO 209 (1994) (English): INDUSTRIAL SAFETY AND HEALTH REGULATIONS – PART 3: OCCUPATIONAL HEALTH AND ENVIRONMENTAL CONTROL

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INDUSTRIAL SAFETY AND HEALTH REGULATIONS – PART 3: OCCUPATIONAL HEALTH AND ENVIRONMENTAL CONTROL

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INDUSTRIAL SAFETY AND HEALTH REGULATIONS – PART 3: OCCUPATIONAL HEALTH AND ENVIRONMENTAL CONTROL

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INDUSTRIAL SAFETY AND HEALTH REGULATIONS – PART 3: OCCUPATIONAL HEALTH AND ENVIRONMENTAL CONTROL

1- SCOPE

This standard is concerned with the Industrial Safety and Health Regulations – Part 3: Occupational Health and Environmental Control.

REGULATIONS – PART 3: OCCUPATIONAL HEALTH AND ENVIRONMENTAL CONTROL

3- OCCUPATIONAL HEALTH AND ENVIRONMENTAL CONTROL

3.1 Ventilation

3.1.1 Definitions

3.1.2 General

3.1.3 Abrasive Blasting

3.1.4 Grinding, Polishing and Buffing Operations

3.1.5 Spray-Finishing Operations

3.1.6 Open Surface Tanks

3.1.7 Battery Charging System

3.1.8 Heat Stress

3.2 Noise

3.3 Radiation

3.3.1 Ionizing Radiation

3.3.2 Nonionizing Radiation

3.4 Accident Prevention Signs, Tags, Signaling and Barricades

3.4.1 Definitions

3.4.2 General

3.4.3 Classification of Signs According to Use

3.4.4 Sign Design

3.4.5 Accident Prevention Tags

3.4.6 Signaling

3.4.7 Barricades

3.5 Medical Services

3.5.1 Definition

3.5.2 General

3.5.3 At the Construction Site

3.6 Confined or Enclosed Space

3.6.1 Definitions

3.6.2 General

3- OCCUPATIONAL HEALTH AND ENVIRONMENTAL CONTROL

3.1 Ventilation

3.1.1 Definitions

- **Abrasive**. A solid substance used in an abrasive blasting operation.
- **Abrasive Blasting**. The forcible application of an abrasive to a surface by pneumatic pressure, hydraulic pressure, or centrifugal force.
- **Abrasive-Blasting Respirator**. A continuous flow air-line respirator constructed so that it will cover the wearer's head, neck, and shoulders to protect him from rebounding abrasive.
- **Abrasive Cutting-Off Wheels**. Organic-bonded wheels, the thickness of which is not more than one forty-eight of the diameter for wheels up to, and including, 50 cm in diameter, and not more than one-sixtieth of the diameter for those larger than 50 cm in diameter, used for a multitude of operations variously known as cutting, cutting off, grooving, slotting, coping and jointing.
- **Belts**. All power-driven, flexible, coated bands used for grinding, polishing or buffing purposes.
- **Blasting Cabinet**. An enclosure where the operator stands outside and operates the blasting nozzle through an opening or openings in the enclosure.
- **Blast Cleaning Room**. A complete enclosure in which blasting operations are performed and where the operator works inside of the room to operate the blasting nozzle and direct the flow of the abrasive material.
- **Clean Air**. Air of such purity that it will not cause harm or discomfort to an individual if it is inhaled for extended periods of time.
- **Disc Wheels**. All power-driven rotatable discs faced with abrasive materials, artificial or natural, and used for grinding or polishing by the abrasive side of the disc.
- **Dust Collector**. A device or combination of devices for separating dust from the air handled by an exhaust ventilation system.

- **Grinding Wheels**. All power-driven rotatable grinding or abrasive wheels, except disc wheels as defined in this standard, consisting of abrasive particles held together by artificial or natural bonds and used for peripheral grinding.
- **Header Pipe (Main Pipe)**. A pipe into which one or more branch pipes enter and which connects such pipes to the remainder of the exhaust system.
- **Hoods and Enclosures**. The partial or complete enclosure around the wheel or disc through which air enters an exhaust system during operation.
- **Horizontal Double-Spindle Disc Grinder**. A grinding machine carrying two power-driven, rotatable, coaxial, horizontal spindles upon the inside ends of which are mounted abrasive disc wheels used for grinding two surfaces simultaneously.
- **Horizontal Single-Spindle Disc Grinder**. A grinding machine carrying an abrasive disc wheel upon one or both ends of a power-driven, rotatable single horizontal spindle.
- **Minimum Maintained Velocity**. The velocity of air movement which must be maintained in order to meet minimum specified requirements for health and safety.
- **Molten Materials Handling Operations**. All operations other than welding, burning, and soldering operations, involving the use, melting, smelting, or pours of metals, alloys, salts, or other similar substances in the molten state. Such operations also include heat treating baths, descaling baths, die casting stereotyping, galvanizing, tinning and similar operations.
- **Particulate-Filter Respirator**. An air purifying respirator, commonly referred to as a dust or a fume respirator, which removes most of the dust or fume from the air passing through the device.
- **Polishing and Buffing Wheels**. All power-driven rotatable wheels composed all or in part of textile fabrics, wood, felt, leather, paper, and may be coated with abrasives on the periphery of the wheel for purposed of polishing, buffing and light grinding.
- **Portable Grinder**. Any power-driven rotatable grinding, polishing, or buffing wheel mounted in such manner that it may be manually manipulated.
- **Respirable Dust**. Airborne dust in sizes (smaller than 10 microns) capable of passing through the upper respiratory system to reach the lower lung passages.
- **Scratch Brush Wheels**. All power-driven rotatable wheels made from wire or bristles, and used for scratch cleaning and brushing purposes.
- **Spray-Finishing Operations**. Spray-finishing operations are methods wherein organic or inorganic materials are utilized in dispersed form for deposit on surfaces to be coated, treated, or cleaned. Such methods of deposit may involve either automatic, manual, or electrostatic deposition but do not include metal spraying or metallizing, dipping, flow coating, roller coating, tumbling, centrifuging, or spray washing and degreasing as conducted in self-contained washing and degreasing machine or system.

- **Spray Room**. A room in which spray-finishing operations not conducted in a spray booth are performed separately from other areas.
- **Surface Coating Operations**. All operations involving the application of protective, decorative, adhesive, or strengthening coating or impregnation to one or more surfaces, or into the space between of any object or material, by means of spraying, spreading, flowing, brushing, roll coating, pouring, cementing, or similar means; and any subsequent draining or drying operations, excluding open-tank operations.
- **Swing-Frame Grinder**. Any power-driven rotatable grinding, polishing, or buffing wheel mounted in such a manner that the wheel with its supporting framework can be manipulated over stationary objects.
- **Ventilation**. The process of supplying or removing air, to or from any space, by natural or mechanical means.
- **Vertical Spindle Disc Grinder**. A grinding machine having a vertical, rotatable power-driven spindle carrying a horizontal abrasive disc wheel.

3.1.2 General

3.1.2.1 Whenever dusts, fumes, mists, vapors, or gases exist or are produced in the course of work, their concentrations shall not exceed the limits specified in Section 4.6. When ventilation is used as control method, the system shall be installed and operated according to the requirements of this section.

3.1.2.2 When controlled ventilation cannot achieve full compliance, protective equipment or other protective measures shall be used to keep the exposure of employees to air contaminants, within the limits prescribed in this section. Any equipment and technical measures used for this purpose must first be approved for each particular use by a competent industrial hygienist. Whenever respirators are used, their use shall comply with Section 5.3.

3.1.2.3 The above subparagraphs do not apply to the exposure of employees to carcinogens. Whenever any employee is exposed to carcinogens, the requirements of Section 4.5 shall apply.

3.1.2.4 Local exhaust ventilation shall be designed to prevent dispersion into the air of dusts, fumes, mists, vapors and gases in concentrations causing harmful exposure at any point of fallout. Such exhaust systems shall be so designed that dusts, fumes, mists, vapors, or gases are not drawn through the work area of employees.

3.1.2.5 Exhaust fans, jets, ducts, hoods, separators, and all necessary appurtenances, including refuse receptacles, shall be so designed, constructed, maintained and operated as to ensure the required protection by maintaining a volume and velocity of exhaust air sufficient to gather dusts, fumes, vapors, or gases from equipment or process.

3.1.2.6 The exhaust system shall be in operation continually during all operations which it is designed to serve. If the employee remains in the contaminated zone, the system shall continue to operate after the cessation of said operation, until the contaminants are removed.

3.1.2.7 Since dust capable of causing disability is of microscopic size, tending to remain for hours in suspension in still air, it is essential that the exhaust system be continued in operation for a time after the work process or equipment served by the same shall have ceased, in order to ensure the removal of the harmful elements to the required extent. For the same reason, employees wearing respiratory equipment should not remove it until the atmosphere is clear.

3.1.2.8 The air outlet from every dust separator, and the dusts, fumes, mists, vapors, or gases collected by an exhaust or ventilating system shall be discharged to the outside atmosphere. Collecting systems which return air to work areas may be used if concentrations which accumulate in the work area do not result in harmful exposure to employees. Dust and refuse discharged from an exhaust system shall be disposed of in such a manner that it will not result in harmful exposure.

3.1.3 Abrasive Blasting

3.1.3.1 **Scope**. This paragraph applies to all operations where an abrasive is forcibly applied to a surface by pneumatic or hydraulic pressure, or by centrifugal force.

3.1.3.2 **Dust Hazards from Abrasive Blasting**

3.1.3.2.1 Abrasives and the surface coatings on the materials blasted are shattered and pulverized during blasting operations and the dust forced will contain particles of respirable size. The composition and toxicity of the dust from these sources shall be considered in making an evaluation of the potential health hazards.

3.1.3.2.2 The concentration of respirable dust or fume in the breathing zone of the abrasive-blasting operator or any other worker shall be kept below the levels specified in Section 4.6.

3.1.3.2.3 Organic abrasives which are combustible shall be used only in automatic systems designed for the material.

3.1.3.2.4 Where flammable or explosive dust mixtures may be present, the construction of the equipment, including the exhaust system and all electric wiring, shall conform to the requirements of Section 4.7. The blast nozzle shall be bonded and grounded to prevent the build-up of static charges. The abrasive blasting enclosure, the ducts, and the dust collector shall be constructed with loose panels or explosion venting areas, located on sides away form any occupied area, to provide for pressure relief in case of explosion.

3.1.3.3 **Blast Cleaning Enclosures**

3.1.3.3.1 Blast-cleaning enclosures shall be exhaust ventilated in such a way that a continuous inward flow of air will be maintained at all openings in the enclosure during the blasting operation.

3.1.3.3.2 All air inlets and access openings shall be baffled or so arranged that by the combination of inward air flow and baffling the escape of abrasive or dust particules into an adjacent work area will be minimized and visible spurts of dust will not be observed.

3.1.3.3.3 The rate of exhaust shall be sufficient to provide prompt clearance of the dust-laden air within the enclosure after the cessation of blasting.

3.1.3.3.4 Before the enclosure is opened, the blast shall be turned off and the exhaust system shall be run for a sufficient period of time to remove the dusty air within the enclosure.

3.1.3.3.5 Safety glass protected by screening shall be used in observation windows, where hard deep-cutting abrasives are used.

3.1.3.3.6 Slit abrasive-resistant baffles shall be installed in multiple sets at all small access openings where dust might escape, and shall be inspected regularly and replaced when needed.

3.1.3.3.7 Doors shall be dust tight when closed. They shall be operable from both inside and outside, except that where there is a small operator access door, the large work access door may be closed or opened from the outside only.

3.1.3.4 **Exhaust Ventilation Systems**

3.1.3.4.1 The construction, installation, inspection, and maintenance of exhaust systems shall conform to good engineering practice.

3.1.3.4.2 When dust leaks are noted, repairs shall be made immediately. The static pressure drop at the exhaust ducts leading from the equipment shall be checked when the installation is completed and periodically thereafter to assure continued satisfactory operation. Whenever, an appreciable change in the pressure drop indicates a partial blockage, the system shall be cleaned and returned to normal operating condition.

3.1.3.4.3 In installations where the abrasive is recirculated, the exhaust ventilation system for the blasting enclosure shall not be relied upon for the removal of fines from the spent abrasive instead of an abrasive separator. An abrasive separator shall be provided for the purpose.

3.1.3.4.4 The air exhausted from blast-cleaning equipment shall be discharged through dust collecting equipment. Dust collectors shall be set up so that the accumulated dust can be emptied and removed without contaminating other working areas.

3.1.3.5 **Personal Protective Equipment**

3.1.3.5.1 **Respiratory Protective Equipment** according to specification approved by GSMO shall be used for protection of personnel against dusts produced during abrasive-blasting operations, see Section 5.3.

3.1.3.5.2 **Abrasive-Blasting Respirators** shall be worn by all abrasive-blasting operators:

When working inside the blast-cleaning rooms, or

When using silica sand in manual blasting operations where the nozzle and blast are not physically separated from the operator in an exhaust ventilated enclosure, or

Where concentrations of toxic dust dispersed by the abrasive blasting may exceed the limits set in Section 4.6 and the nozzle and blast are not physically separated from the operator in an exhaust-ventilated enclosure.

3.1.3.5.3 **Particulate Filter Respirators**, commonly referred to as dust-filter respirators, properly fitted, may be used for short, intermittent, or occasional dust exposures such as cleanup, dumping of dust collectors, or unloading shipments of sand at a

receiving point, where it is not feasible to control the dust by enclosure, exhaust ventilation, or other means.

3.1.3.5.3.1 Particulate filter respirators may be used to protect the operator of outside abrasive-blasting operations only where non-silica abrasives are used on materials having low toxicities.

3.1.3.5.3.2 Particulate filter respirators shall not be used for continuous protection where silica sand is used as the blasting abrasive, or toxic materials are blasted.

3.1.3.5.4 **A Respiratory Protection Program** as defined and described in Section 5.3 shall be established wherever it is necessary to use respiratory protective equipment.

3.1.3.5.5 Safety shoes shall conform to the requirements of Section 5.5.

3.1.3.5.6 Equipment for protection of the eyes and face shall be worn by the operator when the respirator design does not provide such protection and to any other personnel working in the vicinity of abrasive blasting operations. This equipment shall conform to the requirements of Section 5.2.

3.1.3.6 **Air Supply and Air Compressors**. The air for abrasive-blasting respirators shall be free of harmful quantities of dusts, mists, or noxious gases, and shall meet the requirements for air purity set forth in Section 5.3.

3.1.3.7 **Operational Procedures and General Safety**. Dust shall not be permitted to accumulate on the floor or on ledges outside of an abrasive-blasting enclosure, and dust spills shall be cleaned up promptly. Aisles and walkways shall be kept clear of steel shot or similar abrasive which may create a slipping hazard.

3.1.4 Grinding, Polishing and Buffing Operations

3.1.4.1 **Scope**. This paragraph prescribes the use of exhaust hood enclosures and systems in removing dust, dirt, fumes, and gases generated through the grinding, polishing, or buffing of metallic and nonmetallic materials.

3.1.4.2 **Applications**. Wherever dry grinding, dry polishing or buffing is performed, and employee exposure, without regard to the use of respirators, exceeds the permissible exposure limits prescribed in Section 4.6 or other parts of this section, a local exhaust ventilation system shall be provided and used to maintain employee exposures within the prescribed limits.

3.1.4.3 **Hood and Branch Pipe Requirements**

3.1.4.3.1 Hoods connected to exhaust systems shall be used. They shall be designed, located, and placed so that the dust or dirt particles will fall or be projected into the hoods in the direction of the air flow. No wheels, discs, straps, or belts shall be operated in such manner and in such direction as to cause the dust and dirt particles to be thrown into the operator's breathing zone.

3.1.4.3.2 Exhaust systems for grinding wheels on floor stands, pedestals, benches, and special-purpose grinding machines and abrasive cutting-off wheels shall have not less than the minimum exhaust volumes in Table 3.1-1. For any wheel wider than wheel diameters shown in Table 3.1-1 increase the exhaust volume by the ratio of the new width to the width shown. Example:

If wheel width = 11.5 cm then

$$\frac{11.5}{10} \times 17.3 = 19.9 \text{ cu m/min.}$$

3.1.4.3.3 Exhaust system for scratch-brush wheels and all buffing and polishing wheels mounted on floor stands, pedestal, benches, or special-purpose machines shall have not less than the minimum exhaust volume shown in Table 3.1-2.

3.1.4.3.4 Grinding wheels or discs for horizontal single-spindle disc grinders shall be hooded and the hoods shall be connected to branch pipes having exhaust volumes as shown in Table 3.1-3.

3.1.4.3.5 Grinding wheels or discs for horizontal double-spindle disc grinders shall have a hood enclosing the grinding chamber and the hood shall be connected to one or more branch pipes having exhaust volumes as shown in Table 3.1-4.

3.1.4.3.6 Grinding wheels or discs for vertical single-spindle disc grinders shall be encircled with hoods. The hoods shall be connected to one or more branch pipes having exhaust volumes as shown in Table 3.1-5.

Table 3.1-1

Grinding and Abrasive Cutting-Off Wheels

Wheel Diameter (cm)	Wheel Width (cm)	Minimum Exhaust Volume (cu m/min.)
To 23	3.8	6.25
Over 23 to 40	5	11.0
Over 40 to 48	7.5	14.2
Over 48 to 61	10	17.3
Over 61 to 76	12.5	24.9
Over 76 to 91	15	34.0

Table 3.1-2

Buffing and Polishing Wheels

Wheel Diameter (cm)	Wheel Width (cm)	Minimum Exhaust Volume (cu m/min.)
To 23	5	8.5
Over 23 to 40	7.5	14.2
Over 40 to 48	10	17.3
Over 48 to 61	12.5	21.0
Over 61 to 76	15	29.5
Over 76 to 91	15	34.0

Table 3.1-3

Horizontal Single-Spindle Disc Grinders

Disc Diameter (cm)	Exhaust Volume (cu m/min.)
Up to 30	6.25
Over 30 to 48	11.0
Over 48 to 76	14.2
Over 76 to 91	24.9

Table 3.1-4

Horizontal Double-Spindle Grinders

Disc Diameter (cm)	Exhaust Volume (cu m/min.)
Up to 48	14.2
Over 48 to 63	24.9
Over 63 to 76	34.0
Over 76 to 135	50.0
Over 135 to 183	178.0

Table 3.1-5

Vertical Spindle Disc Grinders

Disc Diameter (cm)	One-Half or More of Disc Covered		Disc Not Covered	
	Number[1]	Exhaust cu m/min.	Number[1]	Exhaust cu m/min.
To 50	1	14.2	2	22.0
Over 50 to 76	2	22.0	2	41.9
Over 76 to 135	2	50.0	4	100.0
Over 135 to 184	2	89.0	5	170.0

[1]*Number of exhaust outlets around periphery of hood, or equal distribution provided by other means.*

3.1.4.3.7 Grinding and polishing belts shall be provided with hoods and the hoods shall be connected to branch pipes having exhaust volumes shown in Table 3.1.6.

Table 3.1-6

Grinding and Polishing Belts

Belt Width (cm)	Exhaust Volume (cu m/min.)
Up to 7.5	6.25
Over 7.5 to 12.5	8.5
Over 12.5 to 17.5	11.0
Over 17.5 to 22.5	14.2
Over 22.5 to 28.0	17.3
Over 28 to 33	21.0

3.1.4.4 **Cradles and Swing-Frame Grinders**. Where cradles are used for handling the parts to be ground, polished, or buffed, requiring large partial enclosures to house the complete operation, a minimum average air velocity of 45 m/min. shall be maintained over the entire opening of the enclosure. Swing-frame grinders shall also be exhausted in the same manner as provided for cradles. (See Figure 3.1-9).

3.1.4.5 **Location of Nonenclosing Hoods**. Exhaust hoods that do not enclose the work shall be located as close as possible to the point of contaminant dispersal and shall provide air flow away from the worker to the contaminant source.

3.1.4.6 **Hood and Enclosure Design**. It is the dual function of grinding and abrasive cutting-off wheel hoods to protect the operator from the hazards of bursting wheels as well as to provide a means for the removal of dust and dirt generated.

3.1.4.6.1 Exhaust hoods for floor stands, pedestals, and bench grinders shall be designed in accordance with Figure 3.1-8. The vertical adjustable slide shown in the figure shall be kept in working order and shall be adjusted within 6 mm of the wheel periphery at all times.

3.1.4.6.2 Swing-frame grinders shall be provided with exhaust booths as indicated in Figure 3.1-9.

3.1.4.6.3 Portable grinding operations shall be conducted within a partial enclosure whenever the nature of the work permits. The opening in the enclosure shall be no larger than is actually required in the operation and an average face air velocity of not less than 60 m/min. shall be maintained.

3.1.4.6.4 Hoods for polishing and buffing and scratch-brush wheels shall be constructed to conform as closely to Figure 3.1-10 as the nature of the work will permit.

3.1.4.6.5 Cradle grinding and polishing operations shall be performed within a partial enclosure similar to Figure 3.1-11. The operator shall be positioned outside the working face of the opening of the enclosure. The face opening of the enclosure

should not be any greater in area than that actually required for the performance of the operation.

3.1.4.6.6 Hoods for horizontal single-spindle disc grinders shall be constructed to conform as closely as possible to the hood shown in Figure 3.1.-12. It is essential that there be a space between the back of the wheel and the hood, and a space around the periphery of the wheel of at least 2.5 cm in order to permit the suction to act around the wheel periphery. The opening on the side of the disc shall be no larger than is required for the grinding operation, but must never be less than twice the area of the branch outlet.

3.1.4.6.7 Horizontal double-spindle disc grinders shall have a hood encircling the wheels and grinding chamber similar to that illustrated in Figure 3.1-13. The openings for passing the work into the grinding chamber should be kept as small as possible, but must never be less than twice the area of the branch outlets.

3.1.4.6.8 Vertical-spindle disc grinders shall be encircled with a hood so constructed that the heavy dust is drawn off a surface of the disc and the lighter dust exhausted through a continuous slot at the top of the hood as shown in Figure 3.1-7.

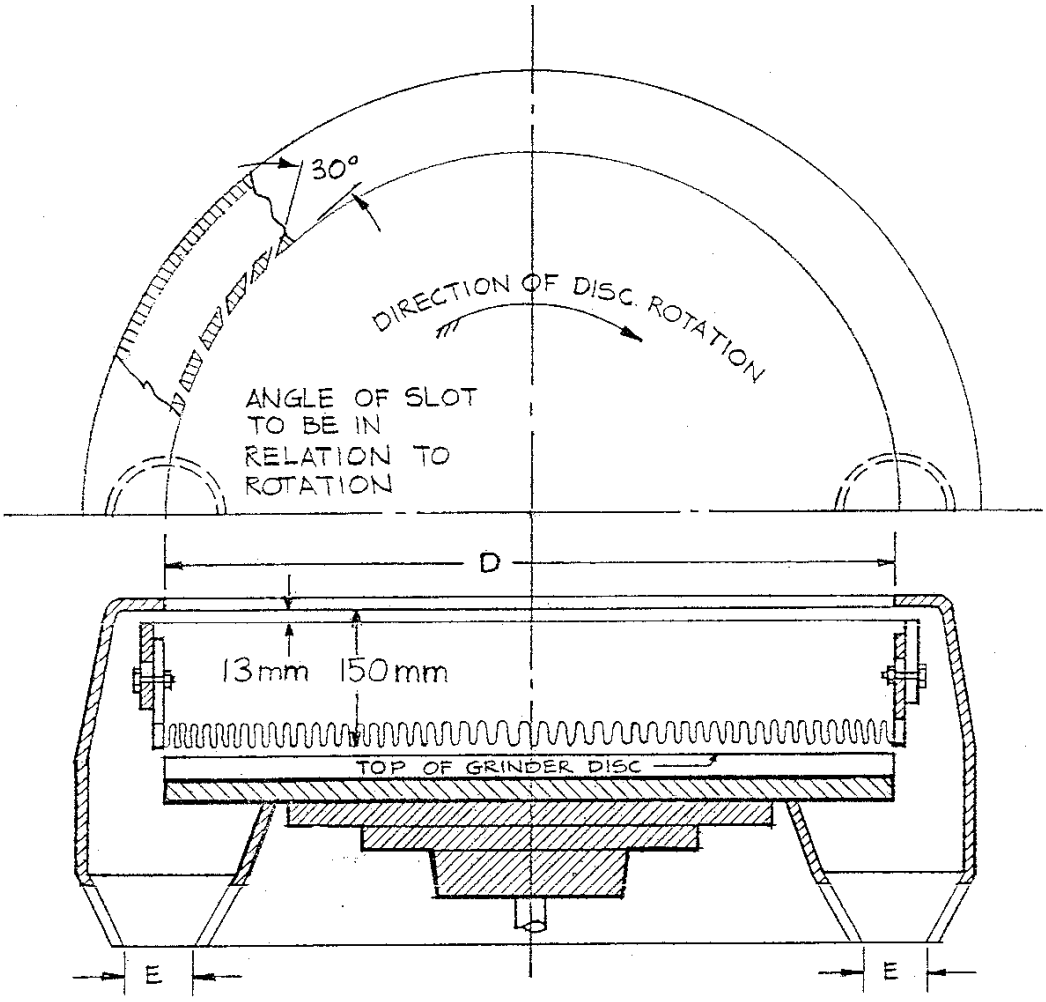

Figure 3.1-7

Vertical Spindle Disc Grinder Exhaust Hood and Branch Pipe Connections

Dia. D mm		Exhaust E		Note
Min	Max	No. Pipes	Dia mm	
	500	1	115	When one-half or more of the disc can be hooded, use exhaust ducts as shown at the left.
Over 500	760	2	100	
Over 750	1350	2	150	
Over 1350	1830	2	200	

	500	2	100	When no hood can be used over disc, use exhaust ducts as shown at left.
Over 500	760	2	140	
Over 750	1350	4	150	

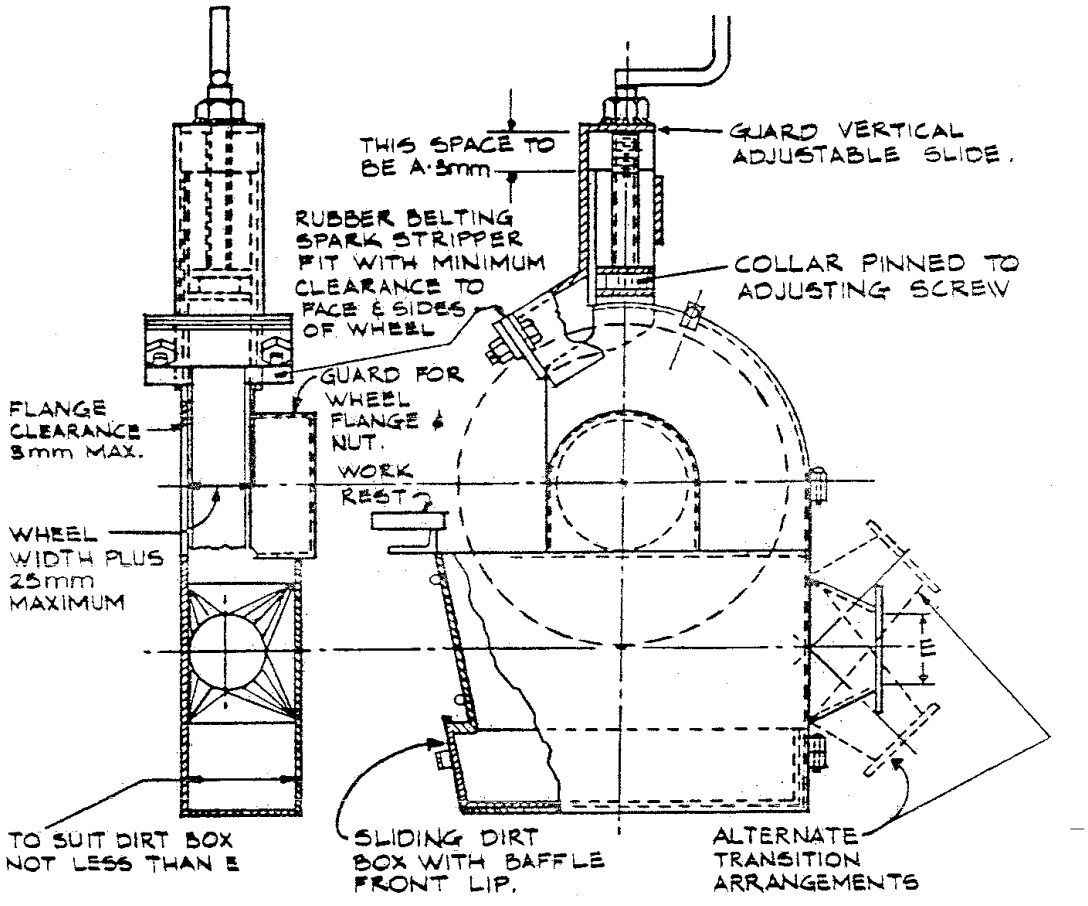

Figure 3.1.8

Standard Grinder Hood

Wheel Dimension			Exhaust Outlet, cm E
Diameter, mm		Width, mm	
Min=d	Max=D		
	230	38	75
Over 230	400	50	100
Over 400	480	75	115
Over 480	610	100	125
Over 610	760	125	150
Over 760	915	150	175

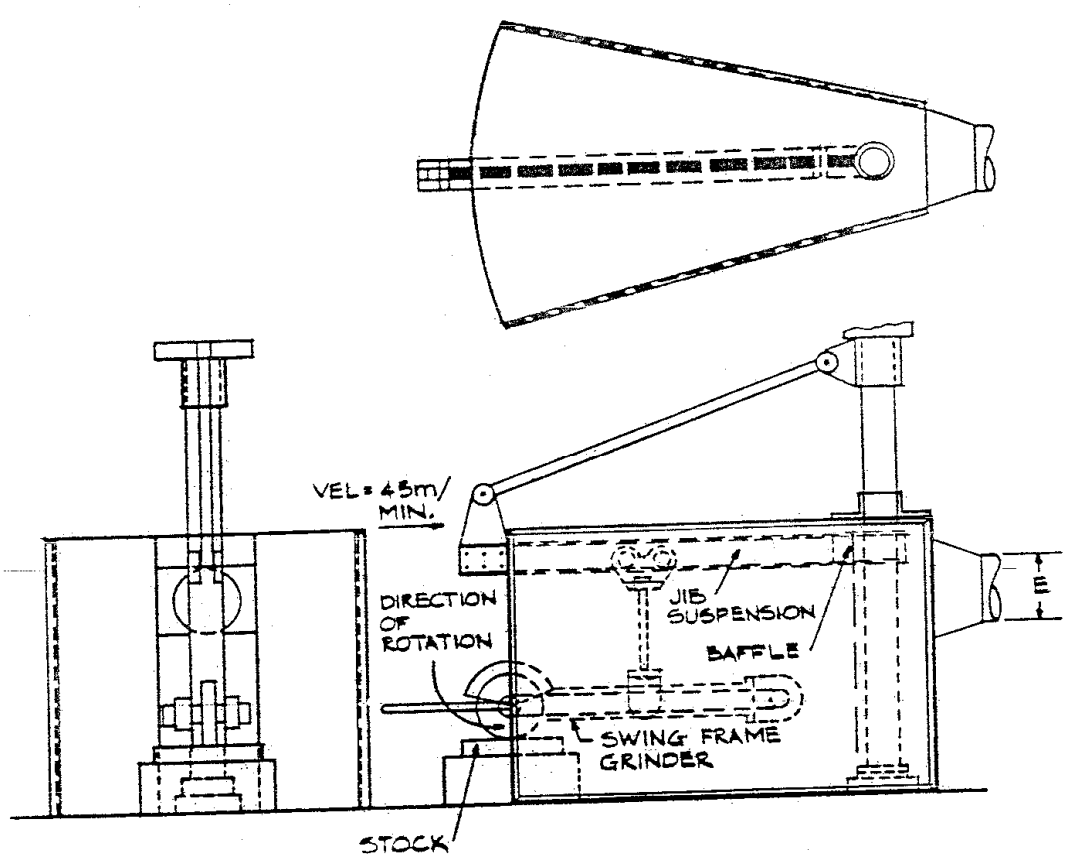

Figure 3.1-9

A Method of Applying an Exhaust Enclosure to Swing-Frame Grinders

NOTE: *Baffle to reduce front opening as much as possible.*

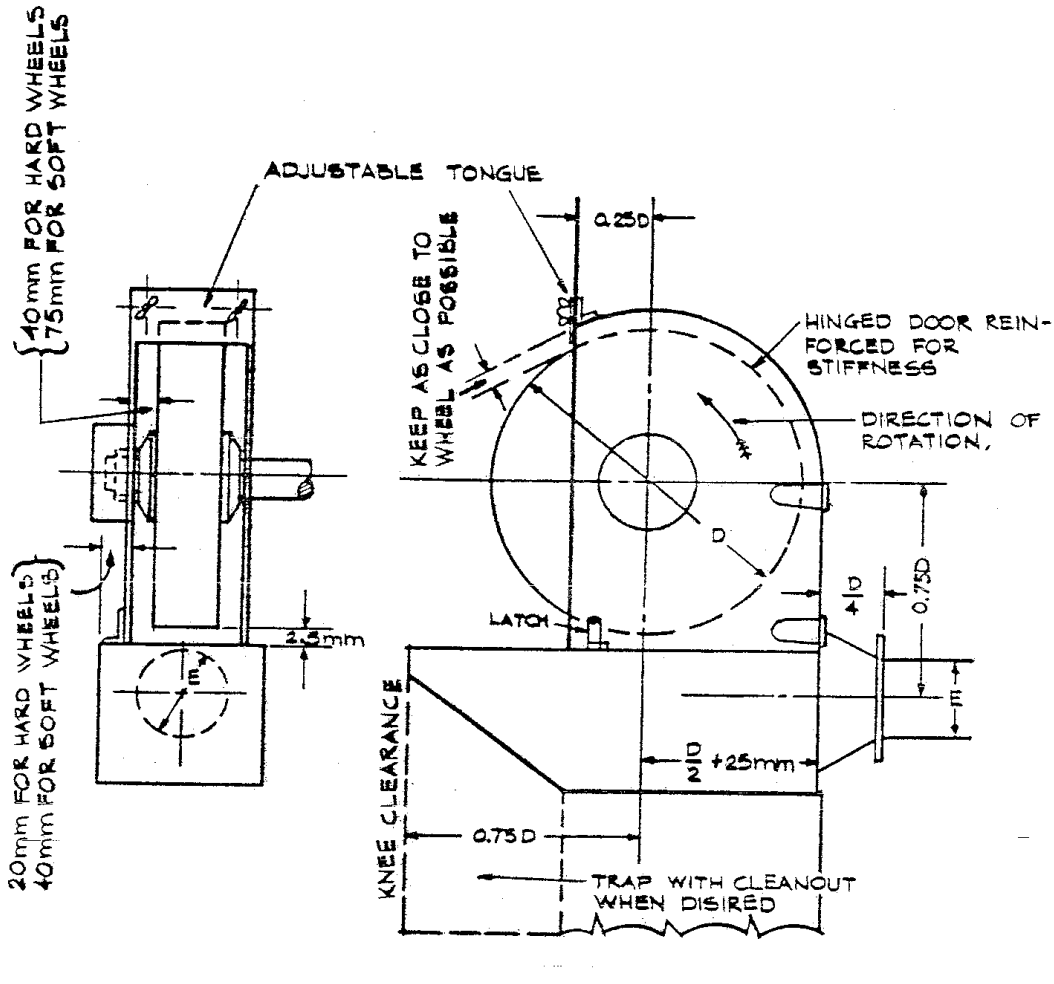

Figure 3.1-10

Standard Buffing and Polishing Hood

Wheel Dimension, mm			Exhaust Outlet, mm E
Diameter		Width	
Min=d	Max=D	Max	
	230	50	90
Over 230	400	75	100
Over 400	480	100	125
Over 480	610	125	140
Over 610	760	150	165

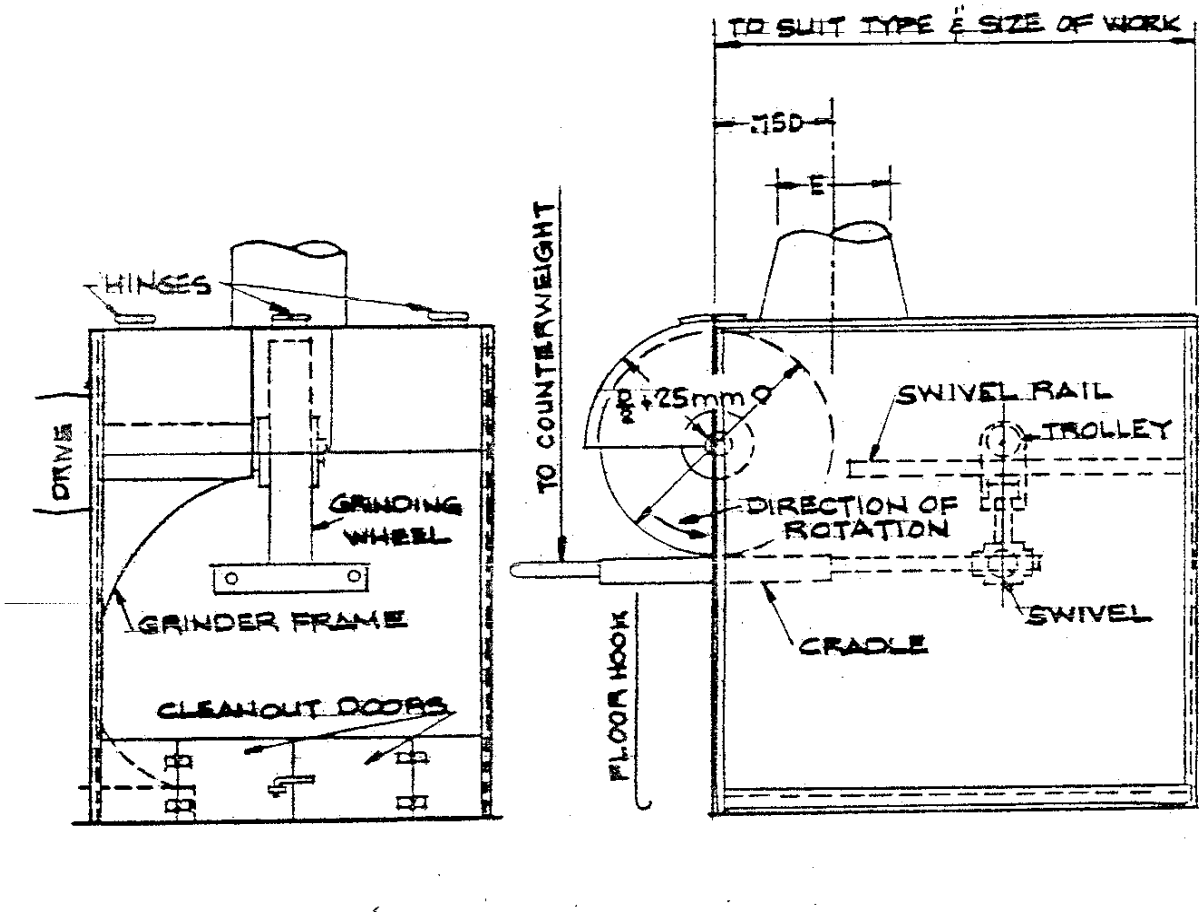

Figure 3.1-11

Cradle Polishing or Grinding Enclosure

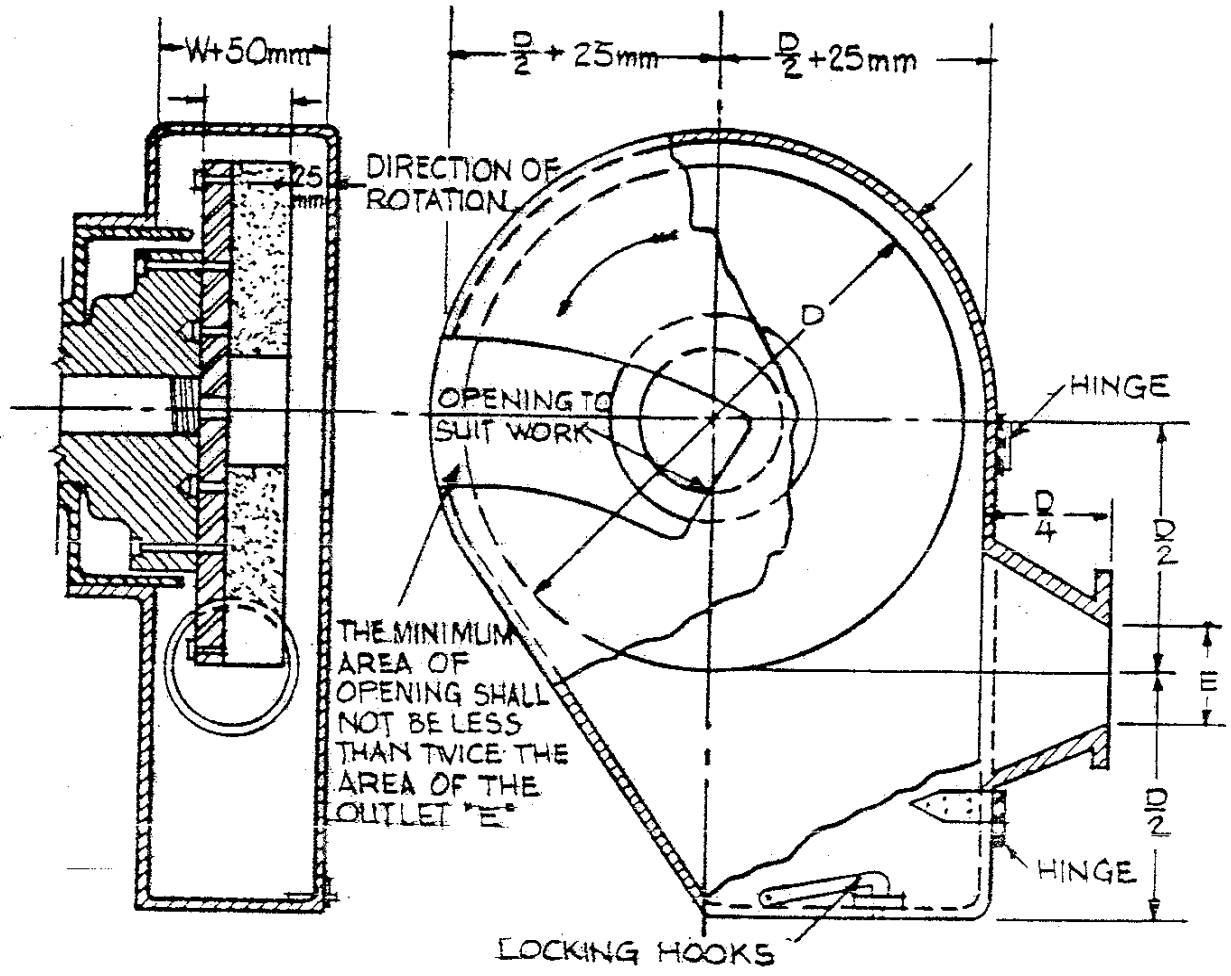

Figure 3.1-12

Horizontal Single-Spindle Disc Grinder Exhaust Hood and Branch Pipe Connections

Dia D mm		Exhaust E
Min	**Max**	**Dia. Mm**
	300	75
Over 300	480	100
Over 480	760	125
Over 760	915	150

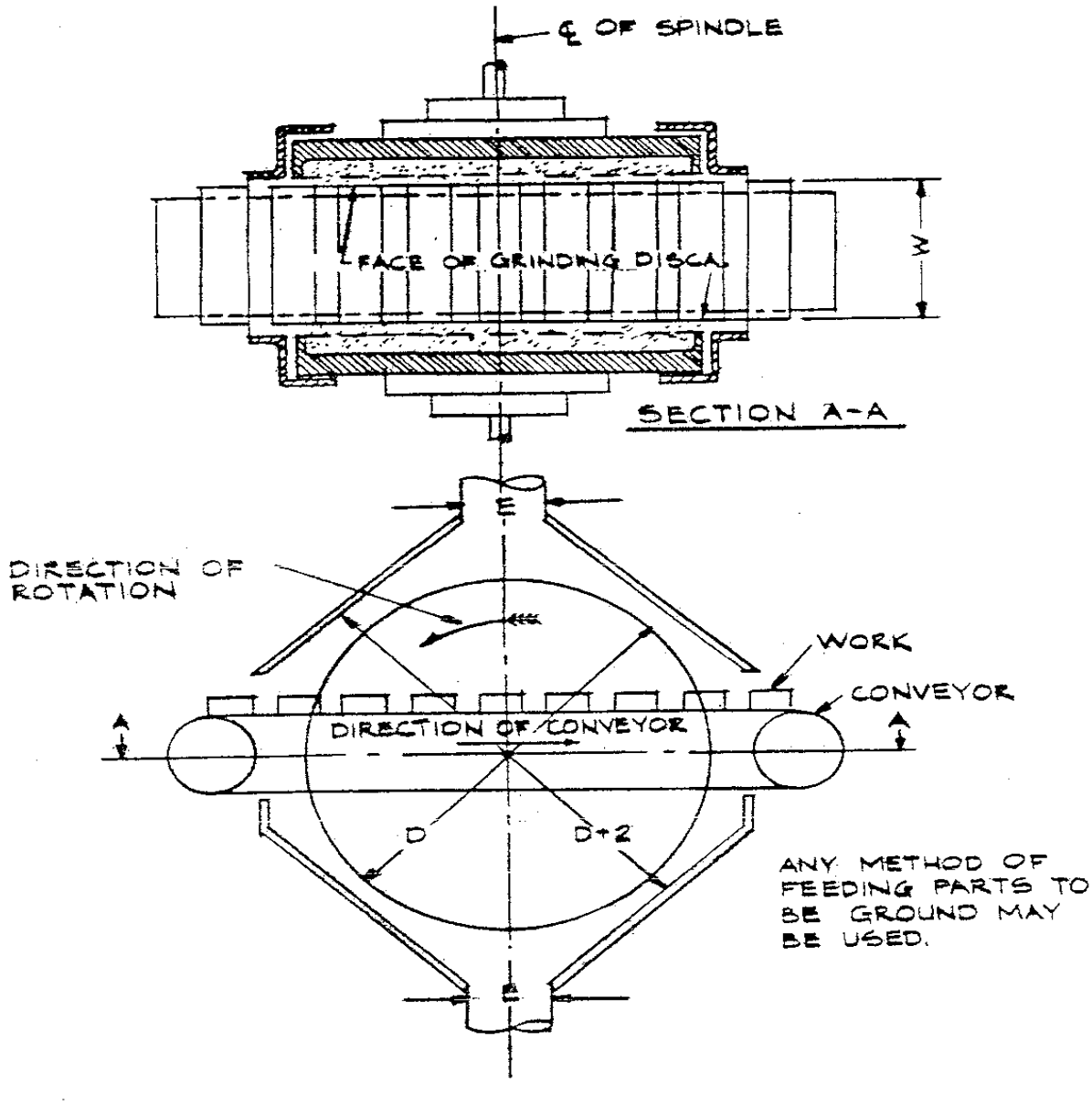

Figure 3.1-13

Horizontal Double-Spindle Disc Grinder Exhaust Hood and Branch Pipe Connections

Disc Dia. mm		Exhaust E		Note
Min	Max	No. Pipes	Dia	
	480	1	125	When width "W" permits, exhaust ducts should be as near heaviest grinding as possible.
Over 480	635	1	160	
Over 635	760	1	175	

3.1.4.6.9 Grinding and polishing belt hoods shall be constructed as close to the operation as possible. The hood should extend almost to the belt, and 2.5 cm wide openings should be provided on either side. Figure 3.1-14 shows a typical hood for a belt operation.

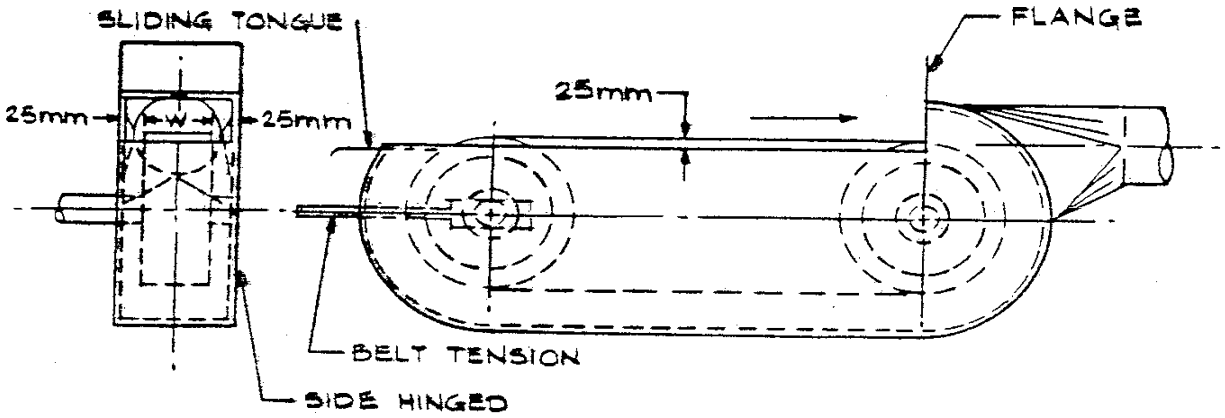

Figure 3.1-14

A Typical Hood for a Belt Operation

Belt Width W. mm	Exhaust Volume, m^3/min.
Up to 75	6.25
75 to 125	8.5
125 to 175	11.0
175 to 225	14.2
225 to 275	17.3
275 to 325	21.0

3.1.5 Spray-Finishing Operations

3.1.5.1 **Scope**. Spray booths or spray rooms are to be used to enclose or confine all spray finishing operations covered by this paragraph.

3.1.5.2 **Location**. Spray-finishing operations shall be located as provided in Section 4.7.

3.1.5.3 **Design and Construction of Spray Booths**. Spray booths shall be designed and constructed in accordance with Section 4.7.

An important design consideration for exhaust systems that are handling potentially explosive dusts, vapors, or gases is provision of adequate exhaust rates to prevent the production of explosive mixtures within the exhaust system. If the volume of contaminant evolved per unit time is known, the exhaust rate needed to dilute the contaminant to a point well below the lower explosive limit for the

contaminant-air mixture can be calculated readily. In general practice the required exhaust rate shall be such that the concentration of contaminant is less than 25 percent of the lower explosive limits.

3.1.5.4 **Ventilation**

3.1.5.4.1 Ventilation shall be provided in accordance with provisions of Section 4.7.

3.1.5.4.2 Inlet or supply ductwork used to transport makeup air to spray booths or surrounding areas shall be constructed or noncombustible materials.

3.1.5.4.3 If negative pressure exists within inlet ductwork, all seams and joints shall be sealed if there is a possibility of infiltration of harmful quantities of noxious gases, fumes, or mists from areas through which ductwork passes.

3.1.5.4.4 Inspection or clean-out doors shall be provided for every 2.7 to 3.3 m of running length for ducts up to 30 cm in diameter. The distance between clean-out doors may be greater for larger pipes. A clean-out door or doors shall be provided for servicing the fan, and where moisture can collect, a drain shall be provided.

3.1.5.4.5 Where ductwork passes through a combustible roof or wall, the roof or wall shall be protected at the point of penetration by open space or fire-resistive material between the duct and the roof or wall. When ducts pass through firewalls, they shall be provided with automatic fire dampers on both sides of the wall.

3.1.5.4.6 Ductwork used for ventilating any process shall not be connected to ducts ventilating any other process or any chimney or flue used for conveying any products of combustion.

3.1.5.5 **Velocity and Air Flow Requirements**

3.1.5.5.1 Except where a spray booth has an adequate air replacement system, the velocity of air into all openings of a spray booth shall be not less than that specified in Table 3.1-15 for the operating conditions specified. An adequate air replacement system is one which introduces replacement air upstream or above the object being sprayed and is so designed that the velocity of air in the booth cross section is not less than that specified in Table 3.1-15 when measured upstream or above the object being sprayed.

Table 3.1.15

Minimum Maintained Velocities Into Spray Booths

Operating conditions for objects completely inside booth		Airflow velocities, m/min.	
	Crossdraft, m/min.	Design	Range
Electrostatic and automatic airless operation contained in booth without operator.	Negligible	15 large booth 30 small booth	15 – 23 23 – 37
Air-operated guns, manual or automatic.	Up to 15	30 large booth 45 small booth	23 – 37 37 – 53
Air-operated guns, manual or automatic.	Up to 30	45 large booth 60 small booth	37 – 53 45 – 75

NOTES:

(1) The effectiveness of the spray booth is dependent upon the relationship of the depth of the booth to its height and width.

(2) Crossdrafts can be eliminated through proper design. Crossdrafts in excess of 30 m/min. shall not be permitted.

(3) Excessive air pressures result in loss of both efficiency and material waste in addition to creating a backlash that may carry overspray and fumes into adjacent work areas.

(4) Booths shall be designed with velocities shown in the column headed "Design." However, booths operating with velocities shown in the column headed "Range" are in compliance with this standard.

3.1.5.5.2 In addition to the requirements of the above subparagraph the total air volume exhausted through a spray booth shall be such as to dilute solvent vapor to at least 25 percent of the lower explosive limit of the solvent being sprayed. The lower explosive limits of the most common solvents used in spray finishing are shown in Table 3.1-16. An example of the method of calculating this volume is given below.

Example: To determine the volume of air in cubic meters necessary to dilute the vapor from 1 liter of solvent to 25 percent of the lower explosive limit (LEL), apply the following formula:

Dilution volume required/liter of solvent =

$$\frac{4\,(100\text{-LEL})\ \text{Cubic Meter of Vapor/Liter}}{\text{LEL}}$$

Using toluene as the solvent.

(1) LEL of toluene from Table 3.1-16, Column 2, is 1.4 percent.

(2) Cubic meter of vapor/liter from Table 3.1-16, Column 1, is .23.

(3) Dilution volume required =

$$\frac{4\ (100-1.4)\ .23}{1.4} = 64.8 \text{ cubic meter/liter}$$

(4) To convert to cubic meter/minute of required ventilation, multiply the dilution volume required/liter of solvent by the number of liters of solvent evaporated/minute.

3.1.5.5.3 When an operator must position himself in a booth downstream of the object being sprayed, an air supplied respirator or other type of respirator shall be used by the operator.

3.1.5.5.4 When downdraft booths are provided with doors, such doors shall be closed when spray painting.

3.1.5.6 **Make-Up Air**

3.1.5.6.1 Clean fresh air, free of contamination from adjacent industrial exhaust systems, chimneys, stacks, or vents shall be supplied to a spray booth or room in quantities equal to the volume of air exhausted through the spray booth.

3.1.5.6.2 Where a spray booth or room receives make-up air through self-closing doors, dampers, or louvers, they shall be fully open at all times when the booth or room is in use for spraying. The velocity of air through such doors, dampers, or louvers shall not exceed 60 m/min. If the fan characteristics are such that the required air flow through the booth will be provided, higher velocities through the doors, dampers, or louvers may be used.

Table 3.1-16

Lower Explosive Limit of Some Commonly Used Solvents

Solvent	Cubic Meters of Vapor/ Liter of Liquid at 21°C	Lower Explosive Limit in Percent by Volume of Air at 21°C
	Column 1	**Column 2**
Acetone	.33	2.6
Amyl Acetate (iso)	.16	*1.0
Amyl Alcohol (n)	.22	1.2
Amyl Alcohol (iso)	.22	1.2
Benzene	.28	*1.4

Solvent	Cubic Meters of Vapor/ Liter of Liquid at 21°C	Lower Explosive Limit in Percent by Volume of Air at 21°C
	Column 1	Column 2
Butyl Acetate (n)	.19	1.7
Butyl Alcohol (n)	.26	1.4
Butyl Cellosolve	.19	1.1
Cellosolve	.25	1.8
Cellosolve Acetate	.17	1.7
Cyclohexanone	.23	*1.1
1.1 Dichloroethylene	.32	5.6
1.2 Dichloroethylene	.32	9.7
Ethyl Acetate	.25	2.5
Ethyl Alcohol	.41	4.3
Ethyl Lactate	.21	*1.5
Methyl Acetate	.30	3.1
Methyl Alcohol	.60	7.3
Methyl Cellosolve	.31	2.5
Methyl Ethyl Ketone	.27	1.8
Methyl n-Propyl Ketone	.23	1.5
Naphtha (VM&P) (24° Naphtha)	.17	0.9
Naphtha (38° Flash) Safety Solvent - Stoddard Solvent	.17	1.1
Propyl Acetate (n)	.20	2.0
Propyl Acetate (iso)	.21	1.8
Propyl Alcohol (n)	.33	2.1
Propyl Alcohol (iso)	.33	2.0
Toluene	.23	1.4
Turpentine	.16	0.8
Xylene (o)	.20	1.0

*At 100°C

3.1.5.6.3 The rating of filters shall be governed by test data supplied by the manufacturer of the filter. A pressure gauge shall be installed to show the pressure drop across the filters. This gauge shall be marked to show the pressure drop at which the filters require cleaning or replacement. Filters shall be replaced or cleaned whenever the air flow through the face of the booth falls below that specified in Table 3.1-15.

3.1.6 Open Surface Tanks

3.1.6.1 **Scope**

3.1.6.1.1 Applies to all operations involving the immersion of materials in liquids, or in the vapors of such liquids, for the purpose of cleaning or altering their surfaces, or adding or imparting a finish thereto, or changing the character of the materials, and their subsequent removal from the liquids or vapors, draining, and drying. Such operations include washing, electroplating, anodizing, pickling, quenching, dyeing, dipping, tanning, dressing, bleaching, degreasing, alkaline cleaning, stripping, rinsing, digesting, and other similar operations, but do not include molten materials handling operations, or surface coating operations.

3.1.6.1.2 Except where specific construction specifications are prescribed in this section, hoods, ducts, elbows, fans, blowers, and all other exhaust system parts, components, and supports thereof shall be so constructed to meet conditions of service and to facilitate maintenance and shall conform to good engineering practice.

3.1.6.2 **Classification of Open-Surface Tank Operations**

3.1.6.2.1 Open-surface tank operations shall be classified into 16 classes, numbered A-1 to D-4, inclusive. (See Tables 3.1-17 and 3.1-18).

3.1.6.2.2 **Determination of Class**. Class is determined by two factors, hazard potential designated by a letter from A to D, inclusive with A having the highest potential, and rate of gas, vapor, or mist evolution designated by a number from 1 to 4, inclusive with 1 having the highest rate (for example, B-3).

3.1.6.2.2.1 Hazard potential is an index, of the severity of the hazard associated with the substance contained in the tank because of the toxic, flammable, or explosive nature of the vapor, gas, or mist produced. The toxic hazard is determined from the concentration, measured in parts by volume of a gas or vapor, per million parts by volume of contaminated air (ppm), or in milligrams of mist per cubic meter of air (mg/cu m), below which ill effects are unlikely to occur to the exposed worker. The concentrations shall be those in Section 4.6.

3.1.6.2.2.2 The relative fire or explosion hazard is measured in degrees Celsius in terms of the closed-cup flash point of the substance in the tank. Detailed information on the prevention of fire hazards in dip tanks may be found in Section 4.8. Where the tank contains a mixture of liquids, other than organic solvents, whose

effects are additive, the hygienic standards of the most toxic component (for example, the one having the lowest ppm or mg/cu m) shall be used, except where such substance constitutes an insignificantly small fraction of the mixture.

3.1.6.2.2.3 Hazard potential shall be determined from Table 3.1-17 with the value indicating greater hazard being used. When the hazardous material may be either a vapor

with a permissible exposure level (PEL) (Ref. Section 4.6) in ppm or a mist in mg/cu m, the permissible exposure level (PEL) indicating the greater hazard shall be used (for example, A takes precedence over B or C; over C or D; C over D. For mixtures of organic solvents, their combined effect, rather than that of either individually, shall determine the hazard potential. In the absence of information to the contrary, the effects shall be considered as additive. If the sum of the ratios of the airborne concentration of each contaminant exceeds unity, the toxic concentration shall be considered to have been exceeded.

Note A:

$$\frac{c1}{PEL_1} + \frac{c2}{PEL_2} + \frac{c3}{PEL_3} + \frac{\ldots\ cn}{PEL_n} \rangle\ 1$$

where:

c = Concentration measured at the operation in ppm.

PEL = Permissible exposure level.

Table 3.1-17

Determination of Hazard Potential

Hazard Potential	Gas or Vapor (ppm)	Mist (mg/cu m)	Flash Point (in degrees C.)
A	0-10	0-0.1	. . . . .
B	11-100	0.11-1.0	Under 38
C	101-500	1.1-10	38 – 93
D	Over 500	Over 10	Over 93

3.1.6.2.2.4 Rate of gas, vapor, or mist evolution is a numerical index, both of the relative capacity of the tank to produce gas, vapor, or mist and of the relative energy with which it is projected or carried upwards from the tank. Rate is evaluated in terms of

- The temperature of the liquid in the tank in degrees Celsius;
- The number of degrees Celsius that this temperature is below the boiling point of the liquid in degrees Celsius;
- The relative evaporation of the liquid in still air at room temperature in an arbitrary scale-fast, medium, slow, or nil; and
- The extent that the tank gases or produces mist in an arbitrary scale-high, medium, low, and nil. (See Table 3.1-18, Note 2). Gassing depends on electrochemical or mechanical processes, the effects of which have to be individually evaluated for each installation (See Table 3.1-18, Note 3).

3.1.6.2.2.5 Rate of evolution shall be determined from Table 3.1-18. When evaporation and gassing yield different rates, the lowest numerical value shall be used.

Table 3.1-18

Determination of Rate of Gas, Vapour, or Mist Evolution[1]

Rate	Liquid Temperature, ^{o}C	Degrees Below Boiling Point	Relative Evaporation[2]	Gassing[3]
1 ….	Over 93	-18 to –6.6	Fast	High
2 ….	65.1 – 93	-6.5 to 10	Medium	Medium
3 ….	34 – 65	-10.1 to 38	Slow	Low
4 ….	Under 34	Over 38	Nil	Nil

NOTE 1: *In certain classes of equipment, specifically vapor degreasers, an internal condenser or vapor level thermostat is used to prevent the vapor from leaving the tank during normal operation. In such cases, rate of vapor evolution from the tank into the workroom is not dependent upon the factors in the table, but rather upon abnormalities of operating procedure, such as carry out of vapors from excessively fast action, drag out of liquid by entrainment of parts, contamination of solvent by water and other materials, or improper heat balance. When operating procedure is excellent, effective rate of evolution may be taken as 4. When operating procedure is average, the effective rate of evolution may be taken as 3. When operation is poor, a rate of 2 or 1 is indicated, depending upon observed conditions.*

NOTE 2: *Relative evaporation rate is determined for 100 percent evaporation as follows: Fast: 0-3 hours; Medium: 3-12 hours; Slow: 12-50 hours; Nil: more than 50 hours.*

NOTE 3: *Gassing means the formation by chemical or electrochemical action of minute bubbles of gas under the surface of the liquid in the tank and is generally limited to aqueous solutions.*

3.1.6.3 **Ventilation**. Where ventilation is used to control potential exposures to workers, it shall reduce the concentration of the air contamination to the degree that a hazard to the worker does not exist.

3.1.6.4 **Control Requirements**

3.1.6.4.1 Control velocities shall conform to Table 3.1-19 in all cases where the flow of air past the breathing or working zone of the operator and into the hoods is undisturbed by local environmental conditions, such as open windows, wall fans, or moving machinery.

3.1.6.4.2 All tanks exhausted by means of hoods which

Project over the entire tank;

Are fixed in position in such a location that the heat of the workman, in all his normal operating positions while working at the tank, is in front of all hood openings; and

Are completely enclosed on at least two sides, shall be considered to be exhausted through an enclosing hood.

3.1.6.4.3 The quantity of air in cu m/min. necessary to be exhausted through an enclosing hood shall be not less than the product of the control velocity times the net area of all openings in the enclosure through which air can flow into the hood.

Table 3.1-19

Control Velocities in Meters/Minute for Undisturbed Locations

Class	Enclosing Hood		Lateral Exhaust[1]	Canopy Hood[2]	
	One Open Side	Two Open Sides		Three Open Sides	Four Open Sides
A-1 and A-2	30	45	45	Do not use	Do not use
A-3 (Note 2), B-1, B-2, and C-1	23	30	30	38	53
B-3, C-2 and D-1 (Note 3)	20	27	23	30	45
A-4 (Note 2), C-3, and D-2 (Note 3)	15	23	15	23	38
B-4, C-4, D-3 (Note 3), and D-4	General room ventilation required				

NOTES:

1. See Table 3.1-20 for computation of ventilation rate.

2. Do not use canopy hood for Hazard Potential A processes.

3. Where complete control of hot water is desired, design as next highest.

3.1.6.4.4 All tanks exhausted by means of hood which do not project over the entire tank, and in which the direction of air movement into the hood or hoods is substantially horizontal, shall be considered to be laterally exhausted. The quantity of air in cu m/min. necessary to be laterally exhausted/sq m of tank area in order to maintain the required control velocity shall be determined from

Table 3.1-20 for all variations in ratio of tank width to tank length. The total quantity of air in cu m/min. required to be exhausted per tank shall be not less than the product of the area of tank surface times the cu m/min./sq m of tank area, determined from Table 3.1-20.

3.1.6.4.5 For lateral exhaust hoods over 1.1 m wide, or where it is desirable to reduce the amount of air removed from the workroom, air supply slots or orifices shall be provided along the side or the center of the tank opposite from the exhaust slots. The design of such systems shall meet the following criteria:

3.1.6.4.5.1 The supply air volume plus the entrained air shall not exceed 50 percent of the exhaust volume.

3.1.6.4.5.2 The velocity of the supply airstream as it reaches the effective control area of the exhaust slot shall be less than the effective velocity over the exhaust slot area.

3.1.6.4.5.3 The vertical height of the receiving exhaust hood, including any baffle, shall not be less than one-quarter the width of the tank.

3.1.6.4.5.4 The supply airstream shall not be allowed to impinge on obstructions between it and the exhaust slot in such a manner as to significantly interfere with the performance of the exhaust hood.

3.1.6.4.5.5 Methods of measuring and adjusting the supply air shall be provided to prevent excessive supply air volumes and pressures. When satisfactory control has been achieved, the adjustable features of the hood shall be fixed so that they will not be altered.

3.1.6.4.6 All tanks exhausted by means of hoods which project over the entire tank, and which do not conform to the definition of enclosing hoods, shall be considered to be overhead canopy hoods. The quantity of air in cubic meters per minute necessary to be exhausted through a canopy hood shall be not less than the product of the control velocity times the net area of all openings between the bottom edges of the hood and the top edges of the tank.

3.1.6.4.7 The rate of vapor evolution (including steam or products of combustion) from the process shall be estimated. If the rate of vapor evolution is equal to or greater than 10 percent of the calculated exhaust volume required, the exhaust volume shall be increased in equal amount.

3.1.6.5 **Spray Cleaning and Degreasing**. Control must be provided for the airborne spray wherever spraying or other mechanical means are used to disperse a liquid above an open-surface tank. Such operations shall be enclosed as completely as possible. The inward air velocity into the enclosure shall be sufficient to prevent the discharge of spray into the workroom. Mechanical baffles may be used to help prevent the discharge of spray. Spray painting operations are covered by Section 4.7.

Table 3.1-20

Minimum Ventilation Rate for Lateral Exhaust

Required minimum control velocity, m/min. (from Table 3.1-19)	Cu m/min./sq. m to maintain required minimum velocities at following ratios tank width (W)/tank length (L). [1,2]				
	0.0-0.09	0.1-0.24	0.25-0.49	0.05-0.99	1.0-2.0
Hood along one side or two parallel sides of tank when one hood is against a wall or baffle.[2] Also for a manifold along tank centerline.[3]					
15	.13	.16	.20	.23	.26
23	.20	.23	.29	.34	.39
30	.26	.33	.39	.46	.52
45	.39	.49	.59	.68	.78
Hood along one side or two parallel sides of free standing tank not against a wall or baffle.					
15	.20	.23	.26	.39	.33
23	.29	.34	.39	.44	.49
30	.39	.46	.52	.59	.65
45	.59	.68	.78	.88	.98

NOTE 1: *It is not practicable to ventilate across the long dimension of a tank whose ratio W/L exceeds 2.0.*

It is undesirable to do so when W/L exceeds 1.0. For circular tanks with lateral exhaust along up to ½ the circumference, use W/L = 1.0; for over one-half the circumference use W/L = 0.5.

***NOTE 2:** Baffle is a vertical plate the same length as the tank, and with the top of the plate as high as the tank is wide. If the exhaust hood is on the side of a tank against a building wall or close to it, it is perfectly baffled.*

***NOTE 3:** Use W/2 as tank width when manifold is along centerline, or when hoods are used on two parallel sides of a tank.*

Tank Width (W) means the effective width over which the hood must pull air to operate (for example, where the hood face is set back from the edge of tank, this set back must be added in measuring tank width). The surface area of tanks can frequently be reduced and better control obtained (particularly on conveyorized system) by using covers extending from the upper edges of the slots toward the center of the tank.

3.1.6.6 Control Means Other Than Ventilation. Tank covers, foams, beads, chips, or other materials floating on the tank surface so as to confine gases, mists, or vapors to the area under the cover or to the foam, bead, or chip layer; or surface tension depressive agents added to the liquid in the tank to minimize mist formation, or any combination thereof, may all be used as gas, mist, or vapor control means for open-surface tank operations, provided that they effectively reduce the concentrations of hazardous materials in the vicinity of the worker below the limits set in accordance with Section 4.6.

3.1.6.7 **Operation**

3.1.6.7.1 The required airflow shall be maintained at all times during which gas, mist, or vapor is emitted from the tank, and at all times the tank, the draining, or the drying area is in operation or use. When the system is first installed, the airflow from each hood shall be measured and corrective action taken if the flow is less than that required. When the proper flow is obtained, the hood static shall be measured and recorded. The hoods and duct system shall be inspected for evidence of corrosion or damage at intervals of not more than 3 months operations, or after a prolonged shutdown period. In any case where the airflow is found to be less than required, it shall be increased to the required value.

3.1.6.7.2 The exhaust system shall discharge to the outer air in such a manner that the possibility of its effluent entering any building is at a minimum. Recirculation shall only be through a device for contaminant removal which will prevent the creation of a health hazard in the room or area to which the air is recirculated.

3.1.6.7.3 A volume of outside air in the range of 90 percent to 110 percent of the exhaust volume shall be provided to each room having exhaust hoods. The outside air supply shall enter the workroom in such a manner as not to be detrimental to any exhaust hood. The airflow of the makeup air system shall be measured on installation. Periodically, thereafter, the airflow shall be remeasured, and corrective action shall be taken when the airflow is below that required. The makeup air shall be uncontaminated.

3.1.6.8 **Personal Protection**

3.1.6.8.1 All persons required to work in such a manner that their feet may become wet shall be provided with rubber or other impervious boots or shoes, rubbers, or wooden-soled shoes sufficient to keep feet dry.

3.1.6.8.2 All persons required to handle work wet with a liquid other than water shall be provided with gloves impervious to such a liquid and of a length sufficient to prevent entrance of liquid into the tops of the gloves. The interior of gloves shall be kept free from corrosive or irritating contaminants.

3.1.6.8.3 All persons required to work in such a manner that their, clothing may become wet shall be provided with such aprons, coats, jackets, sleeves, or other garments made of rubber, or of other materials impervious to liquids other than water, as are required to keep their clothing dry. Aprons shall extend well below the top of boots to prevent liquid splashing into the boots. Provision of dry, clean, cotton clothing along with rubber shoes or short boots and an apron impervious to liquids other than water shall be considered a satisfactory substitute where small parts are cleaned, plated, or acid dipped in open tanks and rapid work is required.

3.1.6.8.4 Whenever there is a danger of splashing, for example, when additions are made manually to the tanks, or when acids and chemicals are removed from the tanks, the employees so engaged shall be required to wear either tight-fitting chemical goggles or an effective face shield. See Section 5.2.

3.1.6.8.5 When, during emergencies as described in subparagraph 3.1.6.10 workers must be in areas where concentrations of air contaminants are greater than the limit set by subparagraph 3.1.6.2 or oxygen concentrations are less than 19.5 percent, they shall be required to wear respirators to reduce their exposure to a level below these limits, and or to provide oxygen. Such respirators shall also be provided in marked, quickly accessible storage compartments built for the purpose, when there exists the possibility of accidental release of hazardous concentrations of air contaminants. Respirators shall be used in accordance with Section 5.3 and persons who may require them shall be trained in their use.

3.1.6.9 **Special Precautions for Cyanide**. Dikes or other arrangements shall be provided so that there is no possibility of intermixing of cyanide and acid in the event of tank rupture.

3.1.6.10 **Inspection, Maintenance, and Cleaning**

3.1.6.10.1 Before cleaning the interior of any tank, the contents shall be drained off, and the cleanout doors shall be opened where provided. All pockets in tanks or pits, where it is possible for hazardous vapors to collect, shall be ventilated and cleared of such vapors.

3.1.6.10.2 Tanks which have been drained to permit employees to enter for the purposes of cleaning, inspection, or maintenance may contain atmospheres which are hazardous to life or health, through the presence of flammable or toxic air contaminants, or through the absence of sufficient oxygen. Before employees shall be permitted to enter any such tank, tests of the atmosphere shall be made to determine if the oxygen concentration is less than 19.5 percent.

3.1.6.10.3 If the tests made indicate that the atmosphere in the tank is unsafe, before any employee is permitted to enter the tank, the tank shall be ventilated until the hazardous atmosphere is removed, and ventilation shall be continued so as to prevent the occurrence of a hazardous atmosphere as long as an employee is in the tank. If ventilation will not clear the tank then employees may enter the tank only

when wearing the appropriate air respirator and complying with subparagraph 5.3.4.3.1.

3.1.6.10.4 If, in emergencies, such as rescue work, when it is necessary to enter a tank which may contain a hazardous atmosphere, a self-contained breathing apparatus shall be used. At least one trained standby employee, with respirator, shall be present in the nearest uncontaminated area. The standby employee must be able to communicate with the employee in the tank and be able to haul him out of the tank with a lifeline if necessary.

3.1.6.10.5 Maintenance work requiring welding or open flame, where toxic metal fumes such as cadmium, chromium, mercury, or lead may be evolved, shall be done only with sufficient local exhaust ventilation to prevent the creation of a health hazard, or be done with respirators.

3.1.6.11 **Vapour Degreasing Tanks**

3.1.6.11.1 In any vapor degreasing tank equipped with a condenser or vapor level thermostat, the condenser or thermostat shall keep the level of vapor below the top edge of the tank by a distance at least equal to one-half the tank width, or at least 1 m, whichever is shorter.

3.1.6.11.2 Where gas is used as a fuel for heating vapor degreasing tanks, the combustion chamber shall be of tight construction, except for such openings as the exhaust flue, and those that are necessary for supplying air for combustion. Flues shall be of corrosion-resistant construction and shall extend to the outer air. If mechanical exhaust is used on this flue, a draft diverter shall be used. Special precautions must be taken to prevent solvent fumes from entering the combustion air of this or any other heater when chlorinated or fluorinated hydrocarbon solvents (for example, trichloroethylene, Freon) are used.

3.1.7 **Battery Charging System**. Ventilation shall be provided to prevent the build up produced hydrogen to a level of 1% by volume or exceed the PEL permitted for sulfuric acid of Table 4.6-1 in the room air at any time. The air should be changed a minimum of three times each hour.

3.1.8 **Heat Stress**

3.1.8.1 **Definitions**

- **Acclimatized**. Bodily or physiological changes that occur in adaption to a new temperature, altitude, climate, environment, or situation.
- **Globe Thermometer**. Consists of a 15 cm diameter hollow copper sphere painted on the outside with a matte black finish and a thermometer with bulb or sensor fixed in the center of the sphere.

3.1.8.2 **General**

3.1.8.2.1 Working conditions that do not comply with Table 3.1-21 shall require one or more of the following control methods:

- Exhaust ventilation used to remove excessive heat and/or humidity.
- Limit time of employee exposure.
- Protective suits for short exposure.

- Refrigerated suit.

3.1.8.2.2 Heat stress conditions under which it is believed that nearly all workers may be repeatedly exposed without adverse health effects are shown in Table 3.1-21.

Table 3.1-21

Permissible Heat Exposure Threshold Limit Values

(Values are given in ^{o}C WBGT)

Work – Rest Regime	Work Load		
	Light	Moderate	Heavy
Continuous Work	30.0	26.7	25.0
75% Work – 25% Rest, Each Hour	30.6	28.0	25.9
50% Work – 50% Rest, Each Hour	31.4	29.4	27.9
25% Work – 75% Rest, Each Hour	32.2	31.1	30.0

Wet Bulb-Globe Temperature Index (WBGT) values are calculated by the following equations:

1. Outdoors with solar load:

   WBGT = 0.7 WB + 0.2 GT + 0.1 DB

2. Indoors or Outdoors with no solar load:

   WBGT = 0.7 WB + 0.3 GT

where:

WBGT = Wet Bulb-Globe Temperature Index

WB = Natural Wet Bulb Temperature

DB = Dry-Bulb Temperature

GT = Globe Thermometer Temperature

3.1.8.2.3 Higher heat exposures than shown in Table 3.1-21 are permissible if the workers have been undergoing medical surveillance and it has been established that they are more tolerant to work in heat than the average worker. Workers shall not be permitted to continue their work when their deep body temperature exceeds 38.0^{o}C.

3.1.8.3 **Work Load Categories**. Heat produced by the body and the environmental heat together determine the total heat load. Therefore, if work is to be performed under hot environmental conditions, the work load category of each job shall be established and the heat exposure limit pertinent to the work load evaluated against the applicable standard in order to protect the worker from exposure beyond the permissible unit.

3.1.8.3.1 The work load category may be established by ranking each job into light, medium, and heavy categories on the basis of type of operation. Where the work load is ranked into one of said three categories, that is,

3.1.8.3.1.1 light work (up to 200 kilogram calories/hr); that is, sitting or standing to control machines, performing light hand or arm work,

3.1.8.3.1.2 moderate work (200-350 kilogram calories/hr), that is, walking about with moderate lifting and pushing,

3.1.8.3.1.3 heavy work (350-500 kilogram calories/hr), that is, pick and shovel work, the permissible heat exposure limit for that work load shall be determined from Table 3.1-21.

3.1.8.3.2 The ranking of the job may be performed either by measuring the worker's metabolic rate while performing his job or by estimating his metabolic rate by the use of the scheme shown in Table 3.1-22.

Table 3.1-22

Assessment of Work Load

Average values of metabolic rate during different activities

A.	Body position and movement	kilogram calories/min.
	Sitting	0.3
	Standing	0.6
	Walking	2.0-3.0
	Walking up hill	Add 0.8 per meter rise

B.	Type of Work		Average kilogram calories/min.	Range kilogram calories/min.
	Hard work	light	0.4	0.2 – 1.2
		heavy	0.9	
	Work with one arm	light	1.0	0.7 – 2.5
		heavy	1.8	

Work with both arms	light	1.5	1.0 – 3.5
	heavy	2.5	
Work with body	light	3.5	2.5 – 15.0
	moderate	5.0	
	heavy	7.0	
	very heavy	9.0	

Light hand work: writing, hand knitting

Heavy hand work: typewriting

Heavy work with one arm: hammering in nails (shoemaker, upholsterer)

Light work with two arms: filing metal, planning wood, raking of a garden

Moderate work with the body: cleaning a floor, beating a carpet

Heavy work with the body: railroad track laying, digging barking trees

Sample Calculation: Using a heavy hand tool on an assembly line

A.	Walking along	2.0 kilogram calories/min.
B.	Intermediate value between heavy work with 2 arms and light work with the body	3.0 kilogram calories/min.
		5.0 kilogram calories/min.
C.	Add for basal metabolism	1.0 kilogram calories/min.
	Total	6.0 kilogram calories/min.

3.1.8.4 **Work-Rest Regimen**

3.1.8.4.1 The permissible exposure limits specified in Table 3.1-21 are based on the assumption that the WBGT value of the resting place is the same or very close to that of the work place. Where the WBGT of the work area is different from that of the rest area a time-weighted average value should be used for both environmental and metabolic heat.

3.1.8.4.2 The time-weighted average metabolic rate (M) shall be determined by the equation:

$$\text{Av. } M = \frac{(M_1) \times (t_1) + (M_2) \times (t_2) + \ldots + (M_n) \times (t_n)}{(t_1) + (t_2) + \ldots + (t_n)}$$

Where M_1, M_2, M_n are estimated or measured metabolic rates for the various activities of the worker during the total time period, t_1, t_2, t_n are the elapsed times in minutes spent at the corresponding metabolic rate as determined by a time study.

3.1.8.4.3 The time-weighted average WBGT shall be determined by the equation:

$$\text{Av. WBGT} = \frac{(WBGT_1)\ x\ (t_1) + (WBGT_2)\ x\ (t_2) + \ . \ . \ . + (WBGT_n)\ x\ (t_n)}{(t_1) + (t_2) \quad + \ . \ . \ . + (t_n)}$$

Where $WBGT_1$, $WBGT_2$, $WBGT_n$ are calculated values of WBGT for the various work and rest areas occupied during total time periods. t_1, t_2, t_n are the elapsed times in minutes spent in the corresponding areas which are determined by a time study. Where exposure to hot environmental conditions is continuous for several hours or the entire work day, the time-weighted averages shall be calculated as hourly time-weighted average, tat is, $t_1 + \ . \ . \ . \ t_n = 120$ min.

3.1.8.4.4 The permissible exposure limits for continuous work are applicable where there is a work-rest regimen of a 5-day work week and an 8-hour work day with a short morning and afternoon break (approximately 15 min.) and a longer lunch break (approximately 30 min.). Higher exposure limits are permitted if additional resting time is allowed. All breaks, including unscheduled pauses and administrative or operational waiting periods during work may be counted as rest time when additional rest allowance must be given because of high environmental temperatures.

It is a common experience that when the work on a job is self-paced, the workers will spontaneously limit their hourly work load to 30-50 percent of their maximum physical performance capacity. They do this either by setting an appropriate work speed or by interspersing unscheduled breaks. Thus the daily average of the workers' metabolic rate seldom exceeds 330 kilogram calories/hr. However, within an 8-hour work shift there may be periods where the workers' hourly average metabolic rate will be higher.

3.1.8.5 **Water and Salt Supplementation**

3.1.8.5.1 During the hot season or when the worker is exposed to artificially generated heat, drinking water shall be made available to the workers in such a way that they are stimulated to frequently drink small amounts, i.e., one cup every 15-20 minutes (about 150 ml).

3.1.8.5.2 The water shall be kept reasonably cool (10^o – 15^oC) and shall be placed close to the workplace so that the worker can reach it without abandoning the work area.

3.1.8.5.3 The workers should be encouraged to salt their food abundantly during the hot season and particularly during hot spells. If the workers are unacclimatized, salted drinking water shall be made available in a concentration of 0.1 percent (1 gram NaC1 to 1.0 liter). The added salt shall be completely dissolved before the water is distributed, and the water shall be kept reasonably cool.

3.1.8.6 **Other Considerations**

3.1.8.6.1 The permissible heat exposure PEL's are valid for light clothing as customarily worn by workers when working under hot environmental conditions. If special clothing is required for performing a particular job and this clothing is heavier or it impedes sweat evaporation or has higher insulation value, the worker's heat tolerance is reduced, and the permissible heat exposure limits indicated in Table 3.1-21 are not applicable. For each job category where special clothing is required, the permissible heat exposure limit shall be established by concerned authorities.

3.1.8.6.2 The recommended heat stress PEL's are valid for acclimated workers who are physically fit.

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3.1.9 **Cold Environment**

3.1.9.1 **Definitions**

- **Frostbite**. The actual freezing of a part of the body by exposure to temperature below freezing.
- **Hypothermia**. Subnormal body temperature.
- **Wind Chill Factor**. The chilling effect of low temperature combined with air movement on the human body.

3.1.9.2 **General**

3.1.9.2.1 **Hypothermia**. The moment the body begins to lose heat faster than it produces it, hypothermia threatens. As heat loss continues, the temperature of the body's inner core falls below normal. When the body temperature drops to 35^{o}C, dexterity is reduced. At 35.6^{o}C, shivering begins. The more the temperature drops, the less effective the brain becomes. If the core temperature drops to 34.4^{o}C the body will stop shivering but every now and then it will experience uncontrollable shaking. If nothing is done, death usually occurs within 1-1/2 hours after shivering starts.

3.1.9.2.2 Frostbite results when crystals form, either superficially or deeply in the fluids and underlying soft tissues of the skin. The effects are more severe if the injured area is thawed and then refrozen. Just before frostbite occurs, the affected skin may be slightly flushed. As frostbite develops the skin changes to white or grayish yellow in appearance. Its onset may be signaled by a ping or tingling sensation in the affected area. If the body has been feeling the effects

of the cold and then stops hurting, investigate – frostbite may have started. Blisters may appear later. The affected part feels intensely cold and numb. As time passes there is mental confusion and impairment of judgment, the victim staggers, eyesight fails, the victim falls and may become unconscious, shock is evident, breathing may cease and if death occurs, it is usually due to heart failure.

3.1.9.2.3 **Wind Chill**. An increase in air movement does not cause the temperature to fall as the air movement increases. Air movement carries warmed air away from the

exposed individual. This causes rapid cooling and a decrease of skin temperatures, permitting tissue freezing or frostbite.

3.1.9.3 **Precautions to Prevent Injuries**

3.1.9.3.1 Several layers of clothing shall be worn in cold environments. One heavy layer of clothing is less effective than several light layers. Some air is trapped between each layer and provides excellent insulation.

3.1.9.3.2 Clothing worn shall provide for some venting of moisture from perspiration.

3.1.9.3.3 Clothing shall be clean and dry.

3.1.9.3.4 Gloves shall be worn in temperatures below $-6^{o}C$. Bare hands shall not touch metal.

3.1.9.3.5 Workers perspiring, wearing damp clothing, or suffering from a cold shall not be permitted to enter a sub-freezing environment.

3.1.9.3.6 Workers shall not move rapidly so that their breathing is through the nose even with a protective mask.

3.1.9.3.7 When hard hats are worn, winter liners shall be used with the hat.

3.1.9.3.8 Boots worn shall be roomy enough to permit movement of the toes with no feeling of tightness.

3.1.9.3.9 Workers shall consume plenty of water to reduce the danger of dehydration.

3.1.9.3.10 In extremely cold environments the "buddy" system shall be used.

3.2 Noise

3.2.1 Definitions

- **dB**. The sound-pressure level in decibels is twenty times the logarithm to the base 10 of the ratio of sound-pressure to the reference sound pressure which is .0002 dyne/sq cm.
- **dBA**. Abbreviation for decibel A scale. The A scale has been selected as it approximates the equal loudness curves at low sound pressure levels.

3.2.2 Protection against the effects of noise exposure shall be provided when the sound levels exceed those show by formula:

$$T = \frac{16}{2^{(.2(L-85))}}$$

T = Time (hrs.) permissible exposure to continuous noise.

L = Sound level measured in dBA on the slow scale of a standard sound level meter

Example: Assume L = 100 dBA

$$T = \frac{16}{2^{(.2(100-85))}} = \frac{16}{2^{3}} = 2 \text{ hr.}$$

3.2.3 Administrative or engineering controls shall be utilized when employees are subjected to time limits exceeding those of the formula. If such controls fail to reduce sound levels, personal protective equipment shall be provided and used to reduce sound levels within the levels of the formula. Plain cotton is not an acceptable protective device.

3.2.4 If the variations in noise level involve maxima at intervals of the 1 second or less, it is to be considered continuous. The maximum continuous sound level shall not exceed 115 dBA.

3.2.5 When the daily noise exposure is composed of two or more periods of noise exposure of different levels, their combined effect should be considered, rather than the individual effect of each. If the sum of the following fractions: C1/T1 + C2/T2..+Cn/Tn exceeds unity, then, the mixed exposure should be considered to exceed the limit value. Cn indicates the total time of exposure at a specified noise level, and Tn indicates the total time of exposure permitted at that level.

3.2.6 Exposure to impulsive or impact noise shall not exceed 140 dBA peak sound pressure level.

3.3 Radiation

3.3.1 **Ionizing Radiation**

3.3.1.1 **Definitions**

- **Calendar Quarter**. Any three month period defined as a period of 13 complete, consecutive calendar weeks.
- **Dose**. Quantity of ionizing radiation absorbed, per unit of mass, by the body or by any portion of the body. When the provisions in this section specify a dose during a period of time, the dose is the total quantity of radiation absorbed, per unit of mass, by the body or by any portion of the body during such period of time. Several different units of dose are in current use.
- **High Radiation Area**. Any area, accessible to personnel, in which there exists radiation at such levels that any portion of the body could receive in any one hour a dose in excess of 100 millirem.
- **Personnel Monitoring Equipment**. Devices designed to be worn or carried by an individual for the purpose of measuring the dose received (for example, film badges, pocket chambers, pocket dosimeters, film rings, etc.).
- **Rad**. A measure of the dose of any ionizing radiation to body tissues in terms of the energy absorbed per unit of mass of the tissue. One rad is the dose corresponding to the absorption of 100 ergs per gram of tissue (1 millirad (mrad) = 0.001 rad).
- **Radiation**. Includes gamma rays, alpha rays, beta rays, neutrons, high-speed electrons, high speed protons, other atomic particles, and X-rays but does not include sound or radio waves, or visible light, or infrared or ultraviolet light.
- **Radiation Area**. Any area accessible to personnel, in which there exists radiation at such levels that a major portion of the body could receive in any

one hour a dose in excess of 5 millirem, or in any 5 consecutive days a dose in excess of 100 millirem.

- **Radiatioactive Material**. Any materials which emits, by spontaneous nuclear desintegration, corpuscular or electromagnetic emanations.
- **Rem**. A measure of the dose of any ionizing radiation to body tissue in terms of its estimated biological effect relative to a dose of 1 roentgen ® of X-rays (1 millirem (mrem) = 0.001 rem). The relation of the rem to other dose units depends upon the biological effect under consideration and upon the conditions for irradiation. Each of the following is considered to be equivalent to a dose of 1 rem: A dose of 1 roentgen due to X- or gamma radiation; A dose of 1 rad due to X- or gamma radiation; A dose of 0.1 rad due to neutrons or high energy protons; A dose of 0.005 rad due to particles heavier than protons and with sufficient energy to reach the lens of the eye:

  For determining exposures to X- or gamma rays up to 3 Mev., the dose limits specified may be assumed to be equivalent to the "air dose". For the purpose of this section "air dose" means that the dose is measured by a properly calibrated appropriate instrument in air at or near the body surface in the region of the highest dosage rate.
- **Restricted Area**. Any area access to which is controlled by the employer for purposes of protection of individuals from exposure to radiation or radioactive materials.
- **Survey**. An evaluation of the radiation hazards incident to the production, use, release, disposal, or presence of radioactive materials or other sources of radiation under a specific set of conditions. When appropriate, such evaluation includes a physical survey of the location of materials and equipment and measurements of levels of radiation or concentrations of radioactive material present.
- **Unrestricted Area**. Any area access to which is not controlled by the employer for purposes of protection of individuals from exposure to radiation or radioactive materials.

3.3.1.2 **Exposure of Individuals to Radiation in Restricted Areas**

3.3.1.2.1 Except as provided in subparagraph 3.3.1.2.2 no employer shall possess, use, or transfer sources of ionizing radiation in such a manner as to cause any individual in a restricted area to receive in any period of one calendar quarter from sources in the employer's possession or control a dose in excess of the limits specified in Table 3.3-1.

Table 3.3-1

	Rems/ Calender Quarter
Whole body: head and trunk; active blood-forming organs; lens of eye; or gonads	1-1/4
Hands and forearms; feed and ankles	18-3/4
Skin of whole body	7-1/2

3.3.1.2.2 An employer may permit an individual in a restricted area to receive dosage to the whole body greater than those permitted under subparagraph 3.3.1.2.1 so long as: During any calendar quarter the dose to the whole body shall not exceed 3 rems; and the dose to the whole body, when added to the accumulated occupational dose to the whole body, shall not exceed 5 (N-18) rems, where "N" equals the individual's age in years at his last birthday; and the employer maintains adequate past and current exposure records which show that the addition of such a dose will not cause the individual to exceed the amount authorized in this subparagraph. "Dose to the whole body" shall be deemed to include any dose to the whole body, gonad, active blood-forming organs, head and trunk, or lens of the eye.

3.3.1.2.3 No employer shall permit any employee who is under 18 years of age to receive in any period of one calendar quarter a dose in excess of 10 percent of the limits specified in Table 3.3-1.

3.3.1.3 **Precautionary Procedures and Personal Monitoring**

3.3.1.3.1 Every employer shall make such surveys as may be necessary for him to comply with the provisions in this section.

3.3.1.3.2 Every employer shall supply appropriate personnel monitoring equipment, such as film badges, pocket chambers, pocket dosimeters, or film rings, to, and shall require the use of such equipment by: Each employee who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 25 percent of the applicable value specified in subparagraph 3.3.1.2.1 and, each employer under 18 years of age who enters a restricted area under such circumstances that he receives, or is likely to receive, a dose in any calendar quarter in excess of 5 percent of the applicable value specified in subparagraph 3.3.1.2.1 and, each employer who enters a high radiation area.

3.3.1.4 **Caution Signs, Labels and Signals**

3.3.1.4.1 Symbols prescribed by this subparagraph shall use the conventional radiation caution colors (magenta or purple on yellow background). The symbol prescribed is the conventional three-bladed design (See Figure 3.3-2).

3.3.1.4.2 Each radiation area shall be conspicuously posted with a sign or signs bearing the radiation caution symbol described above and the words:

CAUTION

RADIATION AREA

3.3.1.4.3 Each high radiation area shall be conspicuously posted with a sign or signs bearing the radiation symbol and the words:

CAUTION

HIGH RADIATION AREA

Each high radiation area shall be equipped with a control device which shall either cause the level of radiation to be reduced below that at which an individual might receive a dose of 100 millirems in one hour upon entry into the area or shall energize a conspicuous visible or audible alarm signal in such a manner that the individual entering and the employer or a supervisor of the activity are made aware of the entry. In the case of a high radiation area established for a period of 30 days or less, such control device in not required.

3.3.1.4.4 Each area or room in which radioactive material is used or stored and which contains any radioactive material in any amount exceeding 10 times the quantity of such material specified in Table 3.3-3 shall be conspicuously posted with a sign or signs bearing the radiation caution symbol described in Figure 3.3-2 and the words:

CAUTION

RADIOACTIVE MATERIALS

3.3.1.4.5 Each container in which is transported, stored, or used a quantity of any radioactive material greater than the quantity of such material specified in Table 3.3-3 shall bear a durable, clearly visible label bearing the radiation caution symbol described in subparagraph 3.3.1.4 and the words:

CAUTION

RADIOACTIVE MATERIALS

The labels required shall state also the quantities and kinds of radioactive materials in the containers and the date of measurement of the quantities. Notwithstanding the provisions of subparagraph 3.3.1.4.4 a label shall not be required for laboratory containers, such as breakers, flasks, and test tubes, used transiently in laboratory procedures, when the user is present; where containers are used for storage.

Table 3.3-3

Material	**Microcuries**
Cobalt 60	1
Iridium 192	10

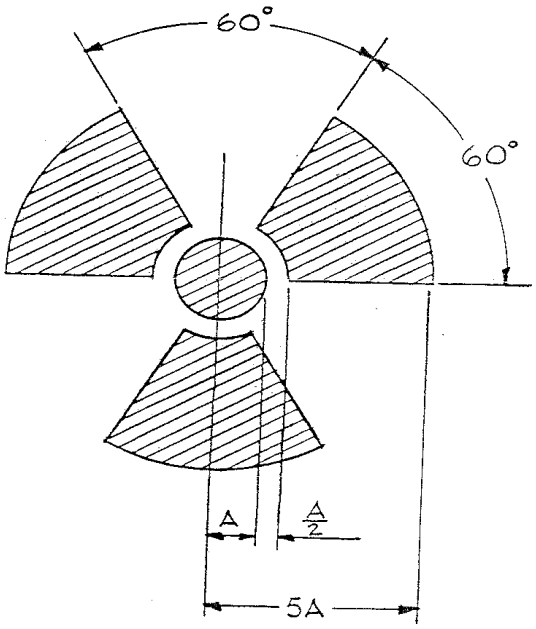

Figure 3.3-2

Radiation Symbol

1. Cross-hatched area is to be magenta or purple.
2. Background is to be yellow.

3.3.1.5 **Immediate Evacuation Warning Signal**

3.3.1.5.1 **Signal Characteristics**

3.3.1.5.1.1 The signal shall be a midfrequency complex (not pure sinusoidal) sound wave amplitude modulated at a subsonic frequency. The complex sound wave in free space shall have a fundamental frequency (f_1) between 450 and 500 hertz (Hz) modulated at a subsonic rated between 4 and 5 hertz.

3.3.1.5.1.2 The signal generator shall not be less than 75 decibels and 10 decibels above ambient noise level at every location where an individual may be present whose immediate, rapid, and complete evacuation is essential.

3.3.1.5.1.3 A sufficient number of signal units shall be installed such that the requirements of the above subparagraph are met at every location where an individual may be present whose immediate, rapid, and complete evacuation is essential.

3.3.1.5.1.4 The signal shall be unique in the plant or facility in which it is installed.

3.3.1.5.1.5 The minimum duration of the signal shall be 1 minute.

3.3.1.5.1.6 The signal-generating system shall respond automatically to an initiating event without requiring any human action to sound the signal.

3.3.1.5.1.7 The signal-generating system shall be designed to incorporate components which enable the system to produce the desired signal each time it is activated within one-half second of activation.

3.3.1.5.1.8 The signal-generating system shall be provided with an automatically activated secondary power supply which is adequate to simultaneously power all emergency equipment to which it is connected, if operation during power failure is necessary, except in those systems using batteries as the primary source of power.

3.3.1.5.1.9 All components of the signal-generating system shall be located to provide maximum practicable protection against damage in case of fire, explosion, corrosive atmosphere, or other environmental extremes consistent with adequate system performance. The signal-generating system shall be designed with the minimum number of components necessary to make it function as intended, and should utilize components which do not require frequent servicing such as lubrication or cleaning.

Where several activating devices feed activating information to a central signal-generator, failure of any activating device shall not render the signal-generator system inoperable to activating information from the remaining devices.

3.3.1.5.2 **Testing**

3.3.1.5.2.1 Initial tests, inspections, and checks of the signal-generating system shall be made to verify that the fabrication and installation were made in accordance with design plans and specifications and to develop a thorough knowledge of

the performance of the system and all components under normal and hostile conditions. Once the system has been placed in service, periodic tests, inspections, and checks shall be made to minimize the possibility of malfunction. Records shall be kept of this information.

3.3.1.5.2.2 Following alterations or revisions to the system, tests, and checks similar to the initial installation tests shall be made. Tests shall be designed to minimize hazards while conducting the tests.

3.3.1.5.2.3 Prior to normal operation the signal-generating system shall be checked physically and functionally to assure reliability and to demonstrate accuracy and performance. Specific tests shall include:

- All power sources.
- Calibration and calibration stability.
- Trip levels and stability.
- Continuity of function with loss and return of required services such as AC or DC power, air pressure, etc.
- All indicators.
- Trouble indicator circuits and signals, where used.
- Air pressure (if used).

Determine that sound level of the signal is within the limit of subparagraph 3.3.1.5.1.2 at all points that require immediate evacuation.

3.3.1.5.2.4 In addition to the initial start up and operating tests, periodic schedule performance tests and status checks must be made to insure that the system is at all times operating within design limits and capable of the required response. Specific periodic tests or checks or both shall include:

- Adequacy of signal activation device.
- All power sources.
- Function of all alarm circuits and trouble indicator circuits including trip levels.
- Air pressure (if used).
- Function of entire system including operation without power where required.
- Complete operational tests including sounding of the signal and determination that sound levels are adequate.

3.3.1.5.2.5 Periodic tests shall be scheduled weekly. The entire system should be operationally tested at least quarterly.

3.3.1.5.2.6 All employees work may necessitate their presence in an area covered by the signal shall be made familiar with the actual sound of the signal-preferably as it sounds at their work location.

3.3.1.5.2.7 Before placing the system into operation, all employees normally working in the area shall be made acquainted with the signal by actual demonstration at work locations.

3.3.1.6 **Exceptions from Posting Requirements. Notwithstanding the Provisions of Subparagraph 3.3.1.4**

3.3.1.6.1 A room or area is not required to be posted with a caution sign because of the presence of a sealed source, provided the radiation level 30 cm from the surface of the source container or housing does not exceed 5 millirem per hour.

3.3.1.6.2 Rooms or other areas on onsite medical facilities containing radioactive material are not required to be posted with caution signs because of the presence of patients, provided that there are personnel in attendance who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive material in excess of the limits established in the provisions of this section.

3.3.1.6.3 Caution signs are not required to be posted at areas or rooms containing radioactive materials for periods of less than eight hours: Provided, that the materials are constantly attended during such periods by an individual who shall take the precautions necessary to prevent the exposure of any individual to radiation or radioactive materials in excess of the limits established in the provisions of this section; and such area or room is subject to the employer's control.

3.3.1.7 **Instructions of Personnel Posting**

3.3.1.7.1 All individuals working in or frequenting any portion of a radiation area shall be informed of the occurrence of radioactive materials or of radiation in such portions of the radiation area; shall be instructed in the safety problems associated

with exposure to such materials or radiation and in precautions or devices to minimize exposure; shall be instructed in the applicable provisions of this section for the protection of employees from exposure to radiation or radioactive materials; and shall be advised of reports of radiation exposure which employees may request pursuant to the regulations.

3.3.1.7.2 Each employer to whom this section applies shall post a current copy of its provisions and a copy of the operating procedures applicable to the work conspicuously in such locations as to insure that employees working in or frequenting radiation areas will observe these documents on the way to and from their place of employment, or shall keep such documents available for examination of employees upon request.

3.3.1.8 **Storage of Radioactive Materials**. Radioactive materials stored in a non-radiation area shall be secured against unauthorized removal from the place of storage.

3.3.1.9 **Waste Disposal**. No employer shall dispose of radioactive material except by transfer to an authorized recipient, or in a manner approved by the concerned authorities.

3.3.1.10 **Notification of Incidents**

3.3.1.10.1 Each employer shall immediately notify the concerned authorities or its duly authorized representative of any incident involving radiation which may have caused or threatens to cause exposure of the whole body of any individual to 25 rems or more of radiation; exposure of the skin of the whole body of any individual to 150 rems or more of radiation; or exposure of the feet, ankles, hands, or forearms of any individual to 375 rems or more of radiation.

3.3.1.10.2 Each employer shall within 24 hours following its occurrence notify the concerned authorities or its duly authorized representative of any incident involving radiation which may have caused or threatens to cause exposure of the whole body of any individual to 5 rems or more of radiation exposure of the skin of the whole body of any individual to 30 rems or more of radiation or exposure of the feet, ankles, hands, or forearms to 75 rems or more of radiation.

3.3.1.11 **Reports of Overexposure and Excessive Levels and Concentrations**

3.3.1.11.1 Each employer shall make a report in writing within 30 days to the concerned authorities of each exposure of an individual to radiation or concentrations of radioactive material in excess of any applicable limit in this section. Each report required shall describe the extent of exposure of persons to radiation or to radioactive material levels of radiation and concentration of radioactive material involved, the cause of the exposure, levels of concentrations; and corrective steps taken or planned to assure against a recurrence.

3.3.1.11.2 In any case where an employer is required pursuant to the provisions of this paragraph to report to the concerned authorities any exposure of an individual to radiation or to concentrations of radioactive material, the employer shall also notify such individual of the nature and extent of exposure. Such notice shall be in writing and shall contain the following statement: "You should preserve this report for future reference".

3.3.1.12 **Records**. Every employer shall maintain records of the radiation exposure of all employees for whom personnel monitoring is required under subparagraph 3.3.1.3 and advise each of his employees of his individual exposure on at least an annual basis.

3.3.1.13 **Disclosure to Former Employee of Individual Employee's Record**. At the request of a former employee an employer shall furnish to the employee a report of the employee's exposure to radiation as shown in records maintained by the employer pursuant to subparagraph 3.3.1.12. Such report shall be furnished within 30 days from the time the request is made, and shall cover each calendar quarter of the individual's employment involving exposure to radiation or such lesser period as may be requested by the employee. The report shall also include the results of any calculations and analysis of radioactive material deposited in the body of the employee. The report shall be in writing and contain the following statement: "You should preserve this report for future reference".

3.3.1.14 **Construction Sites**. In construction and related activities involving the use of sources of ionizing radiation, the pertinent provisions of the paragraph 3.3.1 relating to protection against occupational radiation exposure, shall apply.

Any activity which involves the use of radioactive materials or X-rays, whether or not under license from the concerned authorities shall be performed by competent persons specially trained in the proper and safe operation of such equipment. In the case of materials used under license, only persons actually licensed, or competent persons under direction and supervision of the licensee, shall perform such work.

3.3.2 **Non-ionizing Radiation**

3.3.2.1 **Definitions**

- **Electromagnetic Radiation**. That portion of the spectrum commonly defined as the radio frequency region, which for the purpose of this paragraph shall include the microwave frequency region.
- **Partial Body Irradiation**. Pertains to the case in which part of the body is exposed to the incident electromagnetic energy.
- **Radiation Protection Guide**. Radiation level which should not be exceeded without careful consideration of the reasons for doing so.
- **Symbol**. The overall design, shape, and colouring of the radio-frequency radiation sign shown in Figure 3.3-4.
- **Whole Body Irradiation**. Pertains to the case in which the entire body is exposed to the incident electromagnetic energy or in which the cross section of the body is smaller than the cross section of the incident radiation beam.

3.3.2.2 **Scope**. This subparagraph applies to all radiations originating from radio stations, radar equipment, and other possible sources of electromagnetic radiation such as used for communication, radio navigation, and industrial and scientific purposes.

3.3.2.3 **Radiation Protection Guide**. For normal environmental conditions and for incident electromagnetic energy of frequencies from 10 megahertz to 100,000 megahertz, the radiation protection guide is 10 milliwatt/sq cm as averaged over

any possible 0.1 hour period. This means the following: Power density: 10 milliwatt/sq cm for periods of 0.1 hour or more. Energy density: 1 milliwatt hour/sq cm during any 0.1 hour period. This guide applies whether the radiation is continuous or intermittent. These formulated recommendations pertain to both whole body irradiation and partial body irradiation. Partial body irradiation must be included since it has been shown that some parts of the human body (for example: eyes, testicles) may be harmed if exposed to incident radiation levels significantly in excess of the recommended levels.

3.3.2.4 **Warning Symbol**. The warning symbol for radio frequency radiation hazards shall consist of a red isosceles triangle above an inverted black isosceles triangle, separated and outlined by an aluminum color border. The words "Warning—Radio-Frequency Radiation Hazard" shall appear in the upper triangle. See Figure 3.3-4.

The inclusion and choice of warning information or precautionary instructions is at the discretion of the user. If such information is included it shall appear in the lower triangle of the warning symbol.

3.3.2.5 **Laser Use**

3.3.2.5.1 Only qualified and trained employees shall be assigned to install, adjust, and operate laser equipment.

3.3.2.5.2 Proof of qualification of the laser equipment operator shall be available and in possession of the operator at all times.

3.3.2.5.3 Employees, when working in areas in which a potential exposure to direct or reflected laser light greater than 5 milliwatts exists, shall be provided with antilaser eye protection devices as specified in Section 5.2.

3.3.2.5.4 Areas in which lasers are used shall be posted with warning sign. See Figure 3.3-4.

3.3.2.5.5 Beam shutters or caps shall be utilized, or the laser turned off, when laser transmission is not actually required. When the laser is left unattended for a substantial period of time, such as during lunch hour, overnight, or at change of shifts, the laser shall be turned off.

3.3.2.5.6 Only mechanical or electronic means shall be used as a detector for guiding the internal alignment of the laser.

3.3.2.5.7 The laser beam shall not be directed at employees.

3.3.2.5.8 When used outdoors and it is raining, or when there is dust or fog in the air, the operation of laser systems shall be prohibited where practicable; in any event, employees shall be kept out of range of the area of source and target during such weather conditions.

3.3.2.5.9 Laser equipment shall bear a label to indicate maximum output.

3.3.2.5.10 Employees shall not be exposed to light intensities above:

Direct staring: 1 micro-watt/sq cm;

Incidental observing: 1 milliwatt/sq cm;

Diffused reflected light: 2.5 watts/sq cm.

3.3.2.5.11 Laser unit in operation shall be set up above the heads of the employees, when possible.

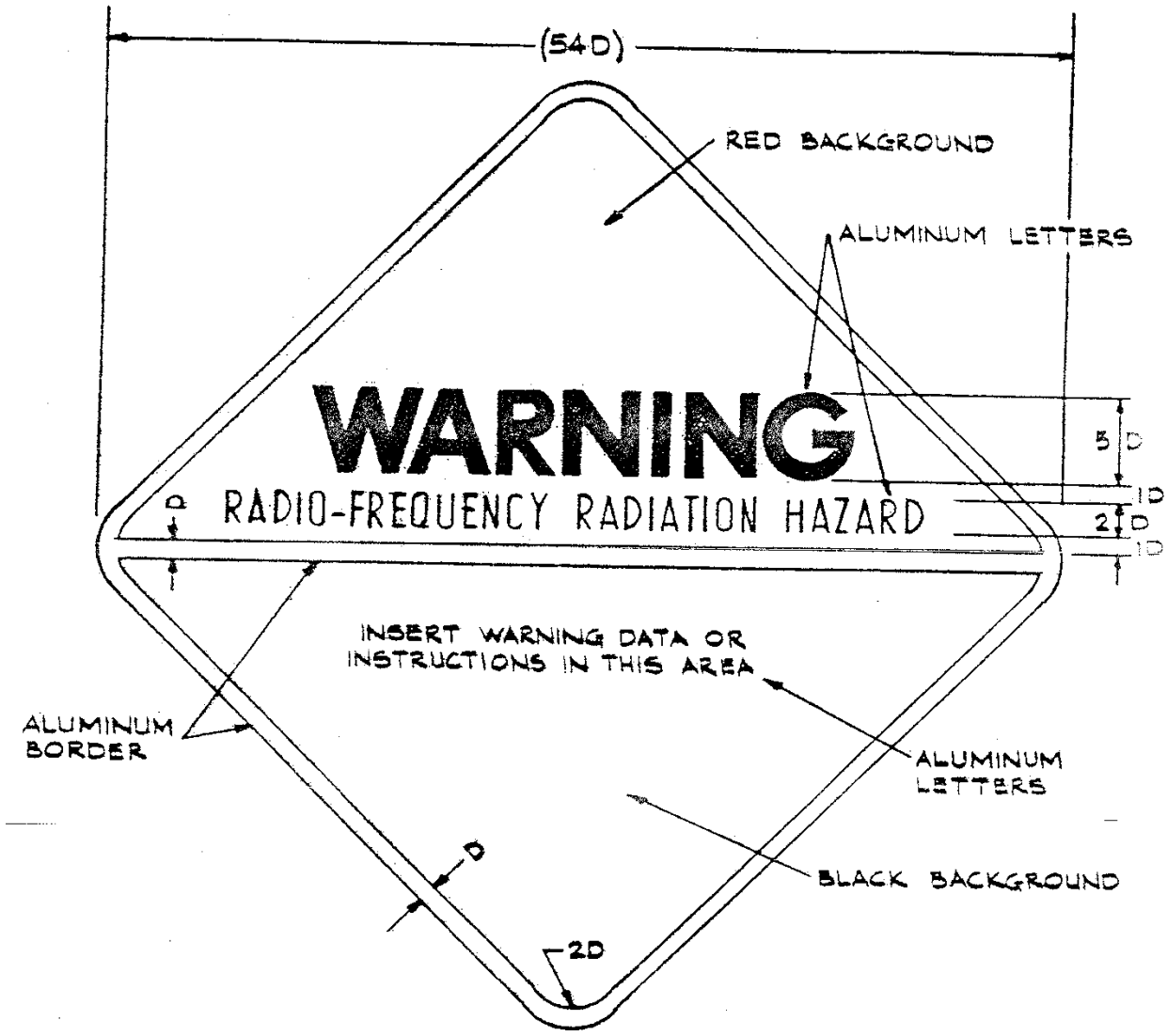

Figure 3.3-4

Radio-Frequency Radiation Hazard Warning Symbol

1. D = Scaling Unit
2. Lettering: Ratio of letter height to thickness of letter lines

   Upper triangle: 5 to 1 Large

   6 to 1 Medium

   Lower triangle: 4 to 1 Small

   6 to 1 Medium

3.4 Accident Prevention Signs, Tags, Signaling and Barricades

3.4.1 Definitions

- **Biological Hazard or Biohazard**. Infectious agents presenting a risk of potential risk to the well being of man.
- **Sign**. A surface on which letters or other markings appear, prepared for the warning of, or safety instructions of, industrial workers who may be exposed to hazards.
- **Tag**. A surface (usually card, paper, pasteboard or some temporary or nonpermanent material) on which letters or markings, or both, appear. They are to be affixed to the device in question by string, wire, or adhesive.

3.4.2 **General**. Signs and symbols required shall be visible at all times when work is being performed, and shall be removed or covered promptly when the hazards no longer exist.

3.4.3 Classification of Signs According to Use

3.4.3.1 Danger signs should be used only where an immediate hazard exists. There shall be no variations in the type of design of signs posted to warn of specific dangers and radiation hazards. All employees shall be instructed that danger signs indicate immediate danger and that special precautions are necessary. Danger signs shall have red as the predominating color.

3.4.3.2 Caution signs shall be used only to warn against potential hazards or to caution against unsafe practices. All employees shall be instructed that caution signs indicate a possible hazard against which proper precaution should be taken. Caution signs shall have yellow as the predominating color.

3.4.3.3 Safety instruction signs shall be used where there is a need for general instructions and suggestions relative to safety measures. Safety instruction signs shall be white with green.

3.4.3.4 Construction areas shall be posted with legible traffic signs at points of hazard. All traffic control signs or devices used for protection of construction workmen shall conform to the Kingdom's standard street and highway signs.

3.4.3.5 The biological hazard warning shall be used to signify the actual or potential presence of a biohazard and to identify equipment, containers, rooms, materials, experimental animals, or combinations thereof, which contain, or are contaminated with, viable hazardous agents.

3.4.3.6 Low overhead clearance limits such as door heights, pipes, lighting, etc. shall be noted with clearance signs. Wording shall be black letters on a white background.

3.4.4 Sign Design

3.4.4.1 All signs shall be furnished with rounded or blunt corners and shall be free from sharp edges, burrs, splinters, or other sharp projections. The ends or heads of bolts or other fastening devices shall be located in such a way that they do not constitute a hazard.

3.4.4.2 The wording of any sign should be easily read and concise. The sign should contain sufficient information to be easily understood. The wording should make a positive, rather than negative suggestion and should be accurate in fact.

3.4.5 **Accident Prevention Tags**

3.4.5.1 Tags are a temporary means of warning all concerned of a hazardous condition, defective equipment, radiation hazards, etc. Tags are not to be considered as a complete warning method, but should be used until a positive means can be employed to eliminate the hazard; for example, a "Do Not Start" tag on power equipment shall be used for a few moments or a very short time until the switch in the system can be locked out; a "Defective Equipment" tag shall be placed on a damaged ladder and immediate arrangements made for the ladder to be taken out of service and sent to the repair shop.

3.4.5.2 "Do Not Start" tags shall be placed in a conspicuous location or shall be placed in such a manner that they effectively block the starting mechanism which would cause hazardous conditions should the equipment be energized.

3.4.5.3 "Danger" tags should be used only where an immediate hazard exits. There should be no variation in the type of design of tags posted or hung to warn of specific dangers. All employees should be instructed that Danger tags indicate immediate danger and that special precautions are necessary.

3.4.5.4 "Caution" tags should be used only to warn against potential hazards or to caution against unsafe practices. All employees should be instructed that Caution tags indicate a possible hazard against which proper precautions should be taken.

3.4.5.5 "Out of Order" tags should be used only for the specific purpose of indicating that a piece of equipment, machinery etc., is out of order and to attempt to use it might present a hazard.

3.4.5.6 "Biological Hazard" tag shall be used to signify the actual or potential presence of a biohazard, to identify equipment, containers, rooms, materials, experimental animals, or combinations thereof, which contain or are contaminated with viable hazardous agents.

3.4.6 **Signaling**

3.4.6.1 When operations are such that signs and barricades do not provide the necessary protection on or adjacent to a highway or street, flagmen or other appropriate controls shall be provided.

3.4.6.2 Signaling directions by flagmen shall conform to the Kingdom's standard.

3.4.6.3 Hand signaling by flagmen shall be by use of red flags at least 45 cm square or sign paddles, and in periods of darkness, red lights.

3.4.6.4 Flagmen shall be provided with and shall wear a red or orange warning garment while flagging. Warning garments worn at night shall be of reflectorized material.

3.4.7 **Barricades**. Barricades for protection of employees shall conform to the follwing: Barricades shall consist of an "A" frame portable structure, with a minimum height of 1 m. Width may be up to 2.4 m long. The top rail shall be 20 to 30 cm wide painted with 15 cm stripes inclined at 45 degrees. Colors shall be orange and white or black and white.

3.5 Medical Services

3.5.1 Definitions. No specific definitions are required.

3.5.2 General

3.5.2.1 The employer shall ensure the ready availability of medical personnel for advice and consultation on matters of industrial health.

3.5.2.2 In the absence of an infirmary, clinic or hospital in near proximity to the workplace which is used for the treatment of all injured personnel, a person or persons shall be adequately trained to render first aid as required by Saudi Labor Law. First aid supplies approved by the consulting physician shall be easily accessible.

3.5.2.3 Proper equipment for prompt transportation of the injured person to a physician or hospital, or a communication system for contacting necessary ambulance service, shall be provided.

3.5.2.4 The telephone numbers of the physicians, hospitals, and ambulances shall be conspicuously posted.

3.5.3 At the Construction Site

3.5.3.1 Provisions shall be made prior to commencement of the project for prompt medical attention in case of serious injury.

3.5.3.2 In addition to complying with subparagraph 3.5.2.2 the first aid kit shall consist of a weatherproof container with individual sealed packages for each type of item. The contents of the first aid kit shall be checked by the employer before being sent out on each job and at least weekly on each job to ensure that the expended items are replaced.

3.6 Confined or Enclosed Space

3.6.1 Definitions

- **Confined or Enclosed Space**. Includes tanks, tank cars, vessels, pits, vaults, shafts or other spaces with one side open to the air and ventilation or exhaust ducts, sewers, tunnels or pipe lines.

3.6.2 General

3.6.2.1 A supervisor who is competent to handle operations shall be placed in charge of the operation.

3.6.2.2 Space shall be tested for contaminants and periodic check tests shall be made to assure an acceptable condition. See Section 4.6.

3.6.2.3 Only when the oxygen content of the air is at least 19.5 percent by volume shall personnel be allowed to enter a tank without protective respiratory equipment.

3.6.2.4 Mechanical exhaust ventilation shall be provided to limit the concentration of flammable vapors of the gas-air mixture to not exceed 25 percent of the lower flammable (explosive) limit.

3.6.2.5 Persons working in a confined or enclosed space shall have a safety harness and life line (Section 5.8) with an attendant if the atmosphere has oxygen deficiency or

contamination sufficient to require respiratory protection. The attendant shall have no other duties. A signal system shall be established.

3.6.2.6 All lines leading into or out of the confined or enclosed space shall be physically disconnected and capped or blanked. The closing of valves with not be a satisfactory substitute.

3.6.2.7 Disconnects in the power to any apparatus in or containing enclosed spaces shall be tagged and locked open whenever men are in the space.

3.6.2.8 Only explosion-proof lighting and equipment shall be used in the space unless the atmosphere has been proven to be nonflammable.

3.6.2.9 The nozzle of air, inert gas, and steam lines or hoses, when used in spaces that contain flammable gases or vapours shall be bonded to the tank or vessel shell. Bonding devices shall not be attached or detached in hazardous concentrations of flammable gases or vapours.